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Editorial correspondence should be addressed to the Editor, Amani, via Tanga, Tanganyika Territory. Matter submitted for publication should preferably be sent through the local member of the Editorial Board.

EDITORIAL NOTES

The attention of every agricultural officer in East Africa, or for that matter anywhere in the tropics or sub-tropics, should be called to what he will find one of the most useful publications that has appeared for many years. This is Bulletin of Miscellaneous Information, Additional Series No. XII, of the Royal Botanic Gardens, Kew, and consists of a compilation by H. C. Sampson of information (supplied by the Departments of Agriculture) of cultivated crop plants of the British Empire and the Anglo-Egyptian Sudan.

As Sir Arthur Hill states, in a foreword to the Bulletin, this is the first attempt that has been made to furnish information about the crop plants of the tropical and sub-tropical parts of the British Empire, and it was made in the belief that it would prove of value to agricultural officers and stimulate the trial of new crops, and more especially of other varieties of crops already under cultivation. That his belief will be justified is immediately apparent from a persual of the Bulletin.

The first part, of about 180 pages, consists of a list in alphabetical order of the genera in which the crop plants are contained. Under each genus is a list, also in alphabetical order, of the species of economic importance.

The information given, where available, for each species comprises the use to which the plant is put, its English and native names in various countries, a list of the countries in which it is: (*a*) indigenous or an early introduction, (*b*) successfully introduced, (*c*) still under trial, (*d*) introduced but its cultivation has subsequently disappeared or been abandoned, (*e*) introduced but has failed to become established.

The second part consists of about 60 pages of crop notes on 20 selected crops, which are mostly "the staple foods of the tropics and sub-tropics on which the indigenous peoples of the British Empire are dependent for their livelihood and existence."

This extremely valuable publication is obtainable, at the price of 6s. 6d., from H.M. Stationery Office.

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It has been decided to reprint, by instalments, a valuable pamphlet, entitled *The Influence of Forests on Climate and Water Supply in Kenya*, by J. W. Nicholson, formerly Forest Adviser to the Governments of Kenya and Uganda. This was published in 1928 and is now out of print and almost unobtainable. A number of requests for it to be sent out on loan from the Amani Library have recently been received.

Not all of Nicholson's conclusions may be accepted by everyone who is interested in the subject, and it is suggested that, after the final instalment has been reprinted, notes and comments on the article might be contributed by the Forest Departments in the several East African territories, by the British East African Meteorological Service, and by anyone else interested.

* * * *

AGAVE AMANIENSIS.

At a meeting of the Tanganyika Sisal Board held on 31st January, 1936, it was agreed, on the suggestion of Mr. Nowell, that *Agave amaniensis* should in future be referred to as "Blue Sisal", this being a description more suitable for ordinary and market uses.

* * * *

PAPAIN.

The Kenya Department of Agriculture recently inquired of the Trade Commissioner for H.M. East African Dependencies as to the present value of papain on the European market. Major Dale, the Trade Commissioner, made an inquiry of the principal firms handling this product, and the following is an extract from their replies:—

> "The present market for papain is very depressed and is much over-produced. We can readily buy from Ceylon at 2/10d. per pound, c.i.f. London. In view of the very limited demand, we would strongly advise that no further production be recommended in any territories under your control, otherwise we shall have a completely demoralized market, and conditions which will dishearten the growers."

The price of 2/10d. per pound quoted above compared with a price of 10/6d. to 10/9d. per pound in November, 1934, when the production of papain in East Africa appeared to offer favourable prospects. The Trade Commissioner points out that it does not appear to be an opportune time for exporting papain from Kenya Colony.

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ANNUAL REPORT OF THE DEPARTMENT OF AGRICULTURE, UGANDA, 1934, PART II (Government Printer, Uganda; Sh. 4).

Part I of this Report, reviewing the position of agriculture and the progress of agricultural administration, for the calendar year 1934, was noticed in Vol. I, No. 3, of this Journal (p. 179).

We have now received Part II, which deals primarily with experimental work, and covers the period from July, 1934, to June, 1935. It is clearly impossible even to summarize the results of the numerous and valuable experiments in progress within the compass of a short

note, and only a few of the more interesting conclusions can be mentioned here.

At the Bugusege Experiment Station, from an experiment conducted over five years to compare the yields of (Arabica) coffee, (*a*) clean weeded, (*b*) with green manure, two cover crops per annum, (*c*) with banana leaf mulch, (*d*) with weed cover dug in twice a year, (*e*) with one cover crop from October to March and clean weeded for the remainder of the year, it appeared that (*a*) (*c*) and (*e*) were all significantly better than either two cover crops or weed cover—the latter being definitely the most inferior. Clean weeding appeared to do best in high-yielding years, whereas banana mulch seemed to avoid large fluctuations in yield.

A very promising strain of cotton has been evolved at the Serere Experimental Station. Derived from the well-known U.4 (which, however, when grown in Uganda produced such short and harsh lint as to be almost worthless), this new strain retains the resistance to drought, Black Arm and Jassid attack of the original U.4, has a high yield, and has been very favourably reported on by the brokers.

Some interesting data are given on the cash returns obtained by interplanting groundnuts in cotton. Using bunch groundnuts, if the planting is done at the proper time, the practice should result in an increased cotton crop as well as in the production of some groundnuts.

Of considerable interest in the Government Entomologist's report is his reasoned statement that there was no evidence that any species of Jassidæ was a pest during the season under review in Uganda. Popular opinion has in the past usually held that because Jassids can cause reddening of cotton leaves, and because cotton with red leaves often gives a poor yield, therefore Jassids are a serious pest. *Lygus*, on the contrary, does more damage to cotton than is commonly recognized, especially to healthy plants that should bear a large crop.

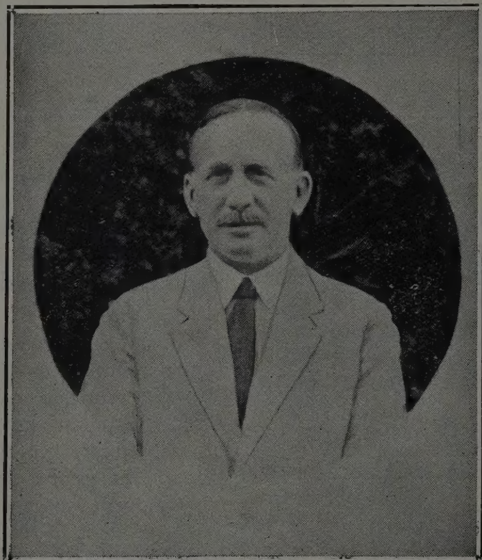
AN APPRECIATION.

In April last, Mr. Nowell went on leave pending retirement, and East Africa has thus lost the services of the first Director of the reconstituted East African Agricultural Research Station, and the first Editor of this Journal.

He was born in Yorkshire in May, 1880, and after serving with the St. John's Ambulance in the South African War, he returned to complete his education, which had not previously been of an especially scientific nature, at the Royal College of Science, South Kensington, and Ruskin College, Oxford. In 1911 he went to the West Indies, where he held successively the posts of Assistant Superintendent in the Department of Agriculture, Barbados; Mycologist and Agricultural Lecturer, Imperial Department of Agriculture for the West Indies, and Assistant Director, Department of Agriculture, Trinidad and Tobago.

His most important publication during this time was "Diseases of Crop Plants in the Lesser Antilles," which appeared in 1923, and still is, and is likely long to remain, the standard work on tropical phytopathology. In 1926 Mr. Nowell was appointed Director of Science and Agriculture, British Guiana, but had scarcely taken up his duties when he was asked to accept the post of Director of the East African Agricultural Research Station, Amani. He arrived at Amani in March, 1927, and after a preliminary examination of the station and tours through the six East African dependencies, he went to England to attend the

Imperial Agricultural Research Conference held in the autumn of 1927. He returned to Amani and began the work



WILLIAM NOWELL,
C.M.G., C.B.E., D.I.C., F.L.S.

of reconstructing the station in March, 1928.

It was not an easy task. A Director had been appointed from 1920 until 1923, but no other staff except a head gardener, in whose sole charge the station remained from 1923 until 1927.

Though it is to be hoped that very many years will pass before Mr. Nowell needs an epitaph, those who knew Amani as it was then, and as it is now, must inevitably be reminded of Wren's: "*Si monumentum requiris, circumspice.*"

Moreover, criticism of the advisability of re-establishing Amani was widespread, ranging from apprehension that the station would interfere with and duplicate the legitimate functions of Departments of Agriculture, to fears that an isolated group of scientists "with their heads in the clouds" would never achieve anything of practical value. That these forebodings have not been fulfilled is in no small measure due to Mr. Nowell.

His abilities as a firm but tactful chairman of meetings and conferences were widely recognized, and it is perhaps fitting that his last activity before leaving Amani was to preside over the Agricultural Research Conference recently held there.

His many friends and acquaintances throughout East Africa will wish both him and Mrs. Nowell a long and prosperous life in England.

The Oil Palm in Uganda

By A. S. THOMAS, *B.Sc., A.I.C.T.A., Assistant Botanist, Uganda.*

The Oil Palm (*Elaeis guineensis* Jacq.) is found in a wild state in many parts of tropical Africa; in the countries on the west coast from the Gambia to Angola; and, in East Africa, it has been recorded from the Sudan, Uganda, Kenya and Tanganyika. Although the palm grows wild in countries on all sides of Uganda, yet in this country it has been reported in the wild state only in one locality, near the western border, in the Semliki Valley.

Wild Oil Palms at Moruba in the Semliki Valley

At Balanga, near the hot springs, there is a considerable stretch of forest in which the palms are abundant; plants of all sizes may be seen, the tallest having trunks thirty feet high; the soil is swampy, and consists of a dark grey clay, approximately neutral in reaction. The trees do not appear to fruit heavily and the fruits are of a poor type, with thin pericarp and thick-shelled nuts; a certain amount of fruit is collected by the Bwamba people and the oil is used for cooking and soap-making. Another small patch of oil palms is growing near a spring at Moruba, a few miles north of Balanga, where the soil is a similar swampy grey clay and the altitude is about the same (2,300 feet).

Although the palms are growing and reproducing themselves under wild conditions, yet it would seem doubtful whether this species should be considered to be truly indigenous to Uganda. It has been stated that oil palms were introduced by natives into many parts of West Africa, and it is quite possible that

the presence of oil palms in the Semliki Valley may be explained in the same way; for the oil palm has not been reported in the wild state from any other part of Uganda, not even from the Budongo and the Mabira Forests, whose vegetation shows strong affinities with that of West African forests; and the places where it grows in the Semliki Valley are visited frequently by natives from the Congo; near Moruba there is a small colony of the Babira, a Congo tribe.

Another example of the introduction of oil palms by natives is furnished by the report that in 1919 there were a number of fine specimens of oil palms distributed throughout Kyagwe, Kyadondo, and Busiro in native compounds. It would seem highly probable that these palms originated from seed brought up from the Coast, either from Mombasa or from Zanzibar, in the first decade of the twentieth century. At that date there were in the Botanic Gardens only three large oil palms, one of which had commenced to fruit; presumably, these had been raised from seed sent from the Semliki Valley during Mr. Dawe's tour in 1906.

In 1909 a sample of fruits from the palms in the Semliki Valley was forwarded to the Imperial Institute. The report on the fruits was unfavourable, as it appeared that they belonged to the poorest class of oil palms, having a thin pulp and thick-shelled nuts. Therefore it was decided that it would not be worth while to attempt the collection and export of kernels.

Seed of better types of oil palms has been imported on several occasions by the Agricultural and Forestry Departments. The first record is of a consignment of seed of West African oil palm received from the Department of Agriculture, Nairobi, in 1918. The seed was distributed throughout the country—to the District Commissioners, to the experimental stations of the Agricultural Department, and to the missions. Some plants from the seed were planted out at Kampala, of which five now remain; the palms are healthy, but do not fruit well.

Another consignment of seed of oil palms was distributed to the various stations of the Agricultural Department in 1921. These were termed "local" and, as at the same time seed from the Semliki Valley was sent to Sumatra, it is probable that the seed distributed locally also came from the same place.

In 1921, a sample of pericarp oil, prepared from the fruit of palms growing in the Botanic Gardens, Entebbe, was forwarded to the Imperial Institute, and received a good report: ". . . The present sample consists of palm oil of normal character which would be classed commercially as 'soft'. The oil is, however, somewhat superior to most of the 'soft' palm oils of commerce in having a lower acidity." But it was considered that there was no immediate prospect of supplies of palm oil for local soapmaking; there were only a few scattered trees in bearing near Kampala, and the collection of fruit in quantity from trees in Bwamba would have been difficult.

During 1927 three batches of seed of oil palms were imported—six pounds of seed from a high-yielding palm in the Experimental Plantation, Serang, Selangor, F.M.S.; three thousand seeds from Buitenzorg, Java; and seeds of Henoi and Tugboi varieties, which were imported by the Forestry Department. None of the seed germinated, with the exception of fourteen of the first batch, and the seedlings were planted out in the Government Plantation, Kampala, in 1928.

In the same year it was decided that it

would be better if all experimental work on oil palms were transferred to one department, and the plot of oil palms at Entebbe, planted by the Forestry Department on the low ground near the Botanic Gardens, was transferred to the Agricultural Department. It is on this plot that the chief experimental work has been performed. Individual records of each tree have been kept since the palms commenced to fruit in 1927.

Cultivated Oil Palms at Entebbe. The palms in the foreground were planted in 1934, while those behind were planted in 1921

Mr. F. M. Dyke, a representative of Lever Bros., visited Uganda in 1930 to investigate the possibilities of the cultivation of oil palms in Uganda, and inspected several localities. As a result of this visit it was decided that trial plots of oil palms should be laid down at Wanyange, near Jinja, and at Serere. Five-acre blocks of palms were planted at each place in 1931, but great difficulty was experienced in getting a good stand of plants. At Wanyange many plants were destroyed by monkeys, and in 1932 nearly half of them had to be replanted, while at Serere the meteorological conditions are almost too dry for oil palms, and by 1934 there were many blank places which were filled in that year.

In 1931 another introduction of oil palm seed was made. The Department of Agriculture, Nigeria, forwarded two hundred and fifty seeds (obtained by self-pollination) of four high-yielding palms at Calabar. These seeds were sown in the Botanic Gardens, Entebbe, but only a small quantity of seedlings was raised:—

No. 222 (ordinary thick-shelled variety)	0
No. 340 (ordinary thin-shelled variety)	4
No. 341 (green - fruited, thick - shelled variety)	10
No. 384 (green - fruited, thin - shelled variety)	10

The seedlings were planted out in 1934

near the existing oil palm plot at Entebbe and have made good growth since that date.

Owing to the various introductions of seed there are now at least five distinct strains of oil palms in cultivation in Uganda:—

(*a*) The wild oil palms in the Semliki Valley and the oldest palms in the Botanic Gardens, Entebbe, which were raised from their seed; these are of a poor type.

(*b*) The oil palms in native farms in Buganda which, it seems, were from seed brought up from the coast; these trees have grown well, but do not seem to be outstanding in the matter of fruit production.

(*c*) The plants which were derived from the West African seed, imported from Kenya in 1918; the palms at Kampala which were raised from this seed are not very good. The origin of the oil palms in the plot at Entebbe, planted by the Forestry Department in 1921, is obscure, but it is probable that they were raised from this seed.

(*d*) Six palms at Kampala, which survive from the fourteen seedlings of the seed of a high-yielding palm in the Experimental Station, Serang, Selangor, F.M.S., which has yielded 217 lb. of fruit in one year. The seedlings were planted out in 1928, and those which are now alive have grown very well; they commenced to fruit in 1933 and, although they are still young, they show promise of yielding heavily.

(*e*) The seedlings of the high-yielding trees at Calabar, received from Nigeria in 1931 and planted out in the Botanic Gardens, Entebbe, in 1934.

Up to the present time the work of selection has been performed only on the plot at Entebbe planted by the Forestry Department in 1921. Fruiting commenced in 1927, and individual tree records have been kept since that date. At first there were about three hundred palms in the plot, planted at a spacing of ten feet by twenty feet; but in order to allow the better development of the palms they have been thinned until only one hundred and five are left. Fruit ripens on this plot throughout the year, although there would appear to be a definite seasonal variation, with maximum production in the months of July, August and September. This variation is shown in Fig. 1, on which are plotted the monthly totals of fruit picked from the plot during the years 1933, 1934, 1935.

There have been great differences between the yields of individual palms. In Fig. 2 there is shown in the form of a histogram the numbers of palms classified according to their total production of fruit up to the end of 1935. It will be seen that most of the palms have produced only a small amount of fruit, but that a few specimens have borne much more heavily than the rest. At first the production of fruit was very slow, but during 1934 and 1935 some palms have yielded as much as two or three hundred pounds of fruit per annum. It is possible that low yields of the palms when they were young was due to faulty pollination and that now that the palms are taller pollination is more complete; for it has been found in Malaya that while artificial pollination increases the yield of young palms, it does not benefit mature palms to the same extent. (1)

There is also considerable variation between the palms on the plot in the character of their fruit; of the one hundred and five palms which are left, thir-

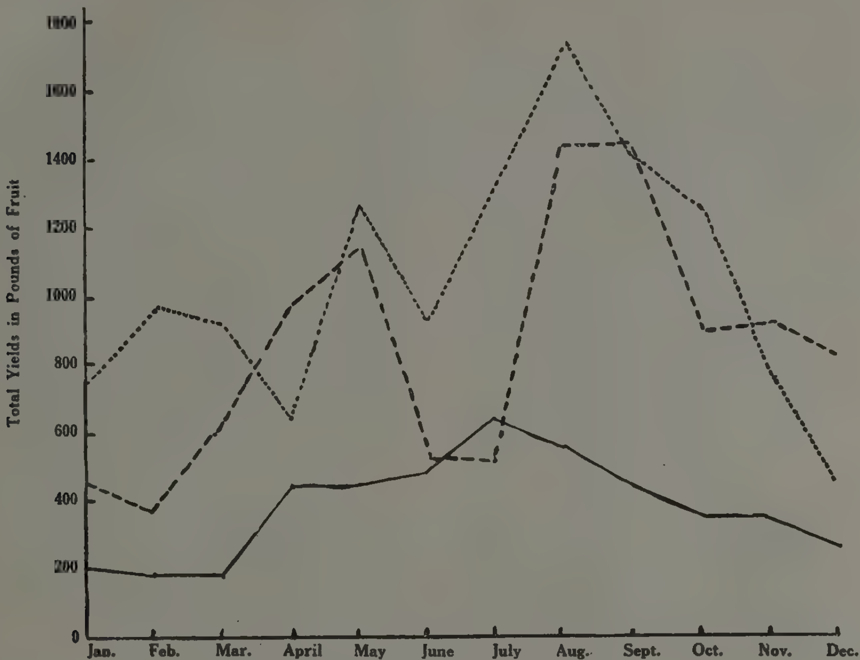


Fig. 1
Monthly Yields of Oil Palm Plot at Entebbe

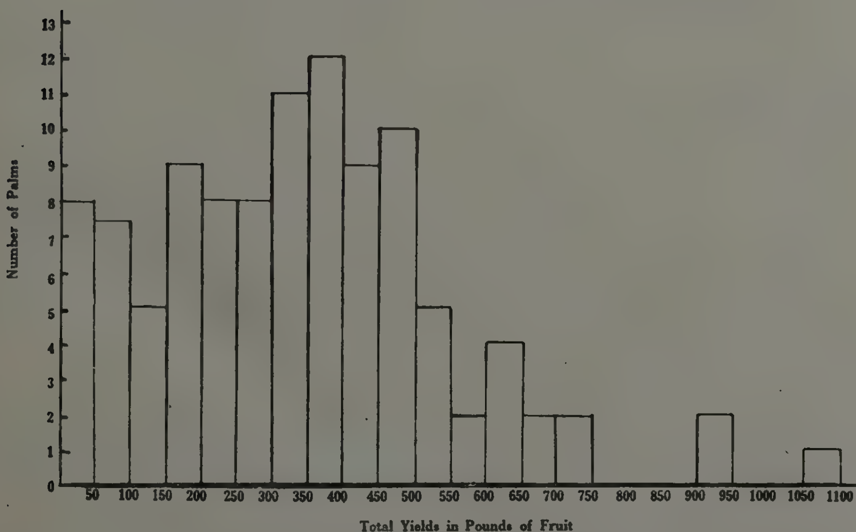


Fig. 2
Yields of Individual Palms at Entebbe 1927-1935

teen are green-fruited. In Table 1 there are shown the size and composition of the fruits of twenty of the palms which had been the heaviest yielders up to 1934. This analysis was performed on samples of two hundred fruits on the outside of the bunches—the fruits inside the bunches were, of course, much smaller.

TABLE 1

Average Fruit Size and Composition of Fruit of Entebbe Oil Palms

Palm No.	Date of Sampling	Average Weight of Fruit	Average Weight of Nuts	Average Weight of Pericarp	Percentage of Pericarp	Average Weight of Kernels
		Gr.	Gr.	Gr.	%	Gr.
6	6–12–34	17·6	9·6	8·0	45	2·5
10	19–7–34	12·0	6·0	6·0	50	1·2
12	5–9–34	25·0	13·4	11·6	46	2·3
19	17–7–35	15·7	1·8	13·9	88	0·9
22*	13–7–34	19·4	8·7	10·7	55	1·4
35	9–8–34	18·3	8·4	9·9	54	1·5
41	23–8–34	15·8	7·3	8·5	54	1·4
43	31–5–35	14·3	6·8	7·5	53	1·4
58	19–7–34	23·4	10·9	12·5	53	1·4
62	13–7–34	17·9	9·8	8·1	45	2·3
65	31–8–35	14·4	9·1	5·3	37	2·6
68	13–7–34	19·6	9·2	10·4	53	1·4
77	13–7–34	20·6	11·1	9·5	46	2·0
78	17–10–34	19·4	11·1	8·3	43	1·8
82	23–8–34	13·8	8·5	5·3	38	1·5
97	23–6–35	10·9	7·9	3·0	28	1·1
125	6–7–34	9·9	4·3	5·6	57	0·9
157	27–9–34	19·0	9·6	9·4	49	1·3
177	13–9–34	23·1	10·8	12·3	53	2·2
232	6–7–34	13·1	7·3	5·8	44	1·5

*Green-fruited.

It may be noticed that almost all the fruit is of a poor type, with a thin pericarp and a thick-shelled kernel; with only one exception, the pericarp is less than 58 per cent of the fruit. This figure is very low in comparison with the standard required in other countries in oil palm breeding; for example, in the Belgian Congo it is stated that a mother tree should have at least 75 per cent of pericarp in the fruit, or, in the case of a very heavy yielding tree, at least 65 per cent (2). The low proportion of pericarp in the fruit of the Entebbe palms would appear to be due to genetical and not to climatic causes; for the fruits of three seedlings at Kampala of the heavy yielding Malay palm contain 58, 68 and 62 per cent of pericarp respectively.

In 1932 seed of eight of the Entebbe palms, which had fruited most heavily before that date, was sown and germinated satisfactorily. Some of the mother trees have continued to be the best yielders in the plot, but three of them have since been excelled by other trees. The area under oil palms at Entebbe was increased in 1934, and short progeny rows of all of these palms were planted at a spacing of thirty feet (triangular). Owing to the swampy nature of the ground, difficulty was found in establishing the plants, but during 1935 they have made good growth.

The Entebbe plot also provided the seed from which were raised the seedlings planted at Wanyange and at Serere in 1931. At Wanyange the plot is somewhat uneven, for much replanting had to be done, but some palms have made good growth and are producing fronds ten or twelve feet long, while a few have commenced to flower and fruit. At Serere the growth has not been so vigorous, and the largest palms have leaves only eight feet long. These plots demonstrate that oil palms will grow in the Eastern Province, especially in the wetter districts. It is possible that they might flourish in the moister places in Teso; for example, at the edge of swamps.

It is highly improbable that the export of palm oil or of palm kernels from Uganda will ever be an economic proposition, owing to the great distance to the coast. But it is possible that the cultivation of the oil palm might be of considerable value to the country, for the oil

would be a useful addition to the native diet, and it might provide material for a local soap-making industry.

When the palms at Entebbe were young their yields were low, but now that the trees are mature some of them are producing quite satisfactory crops; but, as was mentioned above, the fruit is of a poor type.

The palms at Kampala (the progeny of a high-yielding palm in the Federated Malay States) show promise of fruiting well, and it is hoped that the progeny of the Calabar selections, which are growing well at Entebbe, also will prove to be of good type. It has been shown that the oil palm will grown well in different parts of Uganda; but, as many of the palms in the country are of poor types, it is essential that, for any planting that may be done in the future, the seed of the best trees only should be used.

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Mixed Farming in East Africa

II.—Grassland and Arable Dairying in the Trans Nzoia District

By COLIN MAHER, *M.A., Dip. Agric. (Cantab.), A.I.C.T.A., Agricultural Officer, Kenya.*

GENERAL ECOLOGICAL AND AGRICULTURAL CHARACTERISTICS OF THE DISTRICT.

Situation, Climate, Settlement.

The Trans Nzoia is a district of 1,155 square miles in the European areas of Kenya Colony, bounded on the north-west by Mount Elgon, on the north-east by the Cherangani Hills, and to the south-east by the Uasin Gishu lava plateau.

The district enjoys an average rainfall of about 48 inches, which is principally due to instability rains. The rains begin about March or April, and continue until November, June being relatively dry as a rule, while December, January and February constitute the dry season. The south-west of the district receives additional rains, being on the fringe of the area affected by the "lake rains", and up to 60 inches or more are registered on some farms in the region. Towards the north end of Mount Elgon, and towards the Turkana Province, which consists largely of desert, the rainfall falls away to about 30 inches per annum only. July and August are the coolest months and January and February the hottest. The average minimum temperature is 53° F., and the average maximum about 78° F. There are about 300 farmers in the district, who devote their farming operations chiefly to the production of maize and coffee. Many farmers are now turning their attention to the possibility of using dairy stock in the maintenance of the fertility of their maize and coffee lands and supplementing the farm returns by means of the sale of butter or cream. While several farmers have been engaged for many years in the production of farm butter for sale in Uganda, in the mining areas or locally, progress towards mixed farming in the district as a whole has been slow. This is due partly to the shortage of capital, during the period of depressed prices for maize and coffee, for the purchase of stock and fencing materials, and partly to the long distance of the district from the Naivasha Creamery. The recent erection of a creamery at Eldoret, 45 miles from Kitale, the centre of the Trans Nzoia district, should expedite the change over of the farming economy of the district towards arable dairying.

Topography, Soils and Water Supplies.

The land on Mount Elgon is chiefly devoted to coffee-growing. The arable dairying districts are, with the exception of a few square miles of flat land on volcanic tuffs and lavas near Mount Elgon, situated on rolling country, the soil of which is derived from the rocks of the Basement Complex, at altitudes of 5,800 to 6,300 feet. The rocks are gneisses and schists of a composition which varies in different parts of the district, but in general the better soils are derived from the darker coloured gneisses. The soils are sandy loams, which vary in colour from red to pink or grey. They probably fall into the category of Vageler's "red earths", and the deeper the colour the better the soil. The pink or grey soils are in the parts of the district in which the slopes to the river valleys are the most severe, and the soils seem to be

immature soils due to erosion, in geological times, of the deep red soil; the rocks in these latter parts of the Trans Nzoia are often close to the surface, and the farms round the Nzoia valley are typical of the soils described.

Grey soils are also found towards the river valleys where conditions of poor drainage are to be found. Alluvial flats or vleis, in which "murram" may underly a heavy grey soil, are common. The district is cut up into ridges, varying from about 3 per cent to 12 per cent in slope, at the bottom of which run small streams which often originate as springs in the depressions between the ridges where the surface of the land is not far from bedrock. The carving out of the deep valleys probably occurred in pluvial times; the small streams which now exist often run for a mile or so and then disappear in swamps or vleis, rather than join the main drainage system which runs into the Victoria Nyanza. The soils are very subject to erosion—sheet erosion in the past has obviously formed the great vleis—particularly in the parts where permanent streams, such as the Nzoia, run at the bottom of steep-sided valleys. The springs which emerge in the depressions between ridges are usually permanent, but may diminish considerably during the dry season; while unwise cultivation and destruction of vegetative cover by fires or heavy grazing on the slopes may dry up the streams by increasing seasonal run-off and reducing the percolation of the water to the impermeable rock strata. In general the district may be said to be well watered, and bore-holes are invariably successful in reaching water at reasonable depths.

Natural Vegetation.

The vegetation of the virgin country is of the savanna type, with trees, chiefly deciduous, and bushes with a tall grass undergrowth. The trees are usually twenty or thirty feet high, but may be up to forty feet, and the periodic shedding of their leaves contributes materially to the humus content of these soils; the trees come into leaf, with a curious seasonal rhythm, in February, a few weeks before the rains commence.

The species include: *Acacia* sp. (*A. abyssinica* and *A. lahai*), *Erythrina tomentosa, Heeria reticulata, Terminalia torulosa, Bridelia ferruginea, Protea madiensis, Combretum* sp., *Ficus sycamorus, Dombeya* sp., *Bauhinia* sp., *Entada abyssinica.* Tall edaphic or riverine forest is found in the ravines near the streams. Species of trees are found in these situations which are not found in the open savanna.

While the natural bush is very thick and contains large trees, annual bush and grass fires have in some areas considerably thinned out the bush, permanently warped the trees and reduced the grass sward to a tufty and inadequate cover of poor grasses which allows a large degree of sheet erosion to occur at the beginning of the rainy season.

Grassland.

(*a*) *Natural Grassland.*—If the veldt is protected from fires for several years a number of coarse grasses, such as *Cymbopogon* sp. and *Hyparrhenia* sp., tend to multiply, especially in the moister districts, and the grazing deteriorates, from the live stock point of view, in the natural sequence of the vegetation in the reversion to thick bush and growth of savanna trees.

Under-grazed and unburnt natural grassland in the district includes *Setaria* sp. (including Golden Timothy, *Setaria aurea,* and *Setaria trinervia*), Rhodes grass (*Chloris gayana*), Red Oat grass (*Themeda triandra*), Star grasses (*Cyno-*

don sp., including many grasses closely related to *Cynodon dactylon*), *Digitaria* sp., *Brachiaria* sp., *Hyparrhenia* sp., *Panicum maximum* and *Panicum coloratum* (in moist spots), *Amphilophis pertusa* (in the drier districts), *Eragrostis* sp., *Trichopteryx kagerensis, Paspalum scrobiculatum,* etc.

(*b*) *Burnt Veldt Grass.*—Grassland which has often been burnt over tends to have fewer species, and certain grasses, such as *Themeda triandra, Hyparrhenia* sp., *Eragrostis chalcantha,* and *Trichopteryx kagerensis,* predominate, since they are apparently more resistant to fire than the more nutritious grasses, such as the *Cynodon* sp.

(*c*) *Well-grazed Fertile Grassland.*—Kikuyu grass (*Pennisetum clandestinum*) is indigenous to the area, and may constitute an almost pure stand on old *boma* sites where the fertility is very high. Generally, Star grasses (*Cynodon* sp.) of good grazing value and high carrying capacity will occupy the major part of the land in well-controlled grazing where fertility is high. *Paspalum scrobiculatum,* Rhodes grass (*Chloris gayana*), Red Oat grass (*Themeda triandra*), *Brachiaria* sp. and *Setaria* sp. will also be found. Kenya wild white clover (*Trifolium johnstonii*) is indigenous to the area, but is rarely found in natural pastures; indeed, while leguminous plants are very common in the bush, indigenous grazing legumes are uncommon. Amongst these, however, is *Trifolium subrotundum,* an annual clover, which is fairly common and apparently is found palatable by elephants on Mount Elgon.

(*d*) *Reverted Pastures.*—Maize land in the Trans Nzoia is often allowed to revert to pasture, either owing to poverty of the soil or excessive erosion, or as a means of increasing available grazing. The first grasses to enter are the running "couches", such as the Star grasses (*Cynodon* sp.), and the Blue Couch (*Digitaria scalarum*). The next grasses to follow are the *Setaria sp., Brachiaria* sp., and, to a lesser extent, Rhodes grass. The pretty pink feathery head of *Tricholaena rosea* is familiar on poor eroded land or barren subsoil. Other grasses which are the signs of poor land are the *Eragrostis* sp. (including *Eragrostis chalcantha* and *Eragrostis paniciformis*). *Sporobolus indicus* and *Sporobolus filipes* are two other poor fibrous grasses which grow on land of low fertility. The ubiquitous *Eleusine indica* is found on reverted pastures and by roadsides, but is not often seen in old pastures. The Sodom apple bush (*Solanum camplylacanthum*) is an unwelcome entrant into lands that have been allowed to revert to pasture or have been abandoned in the Trans Nzoia.

The rapid spread of rhizomatous grasses in fallowed maize land renders the return of these lands to arable cultivation rather troublesome in a district that is as moist as the Trans Nzoia.

The Management of the Feeding of Cattle in the Trans Nzoia and Similar Districts in East Africa.

Introduction.

There is perhaps no branch of scientific agriculture which has been more neglected in Kenya than that of the feeding of dairy cows. While no owner of racehorses attempts to train his animals on thistles and no motorist tries to run his engine on crude oil, many a dairy farmer in Kenya attempts, with scant success, to produce milk and keep "condition" on high-grade or pure-bred cows which are fed on coarse fibrous grazing, often unsupplemented by any other foodstuffs. Yet there are probably few dairying countries in which farmers are able to

raise or purchase foodstuffs as cheaply as they can in Kenya. The man who is unable to improve his grazing or to provide extra food for his cows in many instances might be better advised to keep selected native or low-grade cows. These will not give as much milk, but will make better use of the rough food available and will keep in better trim.

An advance in animal husbandry in England was made in the eighteenth century when the introduction of clover and roots enabled the farmers to maintain their animals without the disastrous losses in stock which were apt to occur in medieval winters.

With Boutflour as the most notable high priest, a further advance was made during the present century with the cult of quality before quantity in cattle foods. The technique of rationing has been standardized during the last ten years by the late T. B. Wood, by H. E. Woodman and others.

While animals can be bred which, with appropriate feeding, can be induced to yield well over a thousand gallons a year, it is widely thought that more robust animals, which yield rather less but which do not require such delicate feeding, are more economic. This certainly applies to Kenya conditions and to the production of milk for the sale of butterfat. It is necessary to observe, however, that a robust constitution does not necessarily imply a "beefy" configuration.

It must be admitted that feeding has had as much as breeding to do with the production of the high-yielding animals which are the pride of the English dairy industry, and which enable English farmers to conduct a profitable trade in the export of pedigree stock to other countries. This intimate relationship between herd management and breeding seems to have escaped the attention of a considerable number of dairy farmers in Kenya; many a herd of bony animals with staring coats prowls over bare, dusty veldt or tussocky grass as testimony to the fact that a valuable pure-bred bull is not always a short cut to success in dairy farming, and that breeds which require intensive treatment are not the most suitable for rough ranching conditions. A farmer may exhibit with pride an ill-conditioned animal, which he says is giving two or two-and-a-half gallons a day, although in fact it has the appearance of an animal which, with correct feeding, should be capable of giving four or five gallons a day. Those farmers who are interested in the scientific feeding of their live stock should obtain the following bulletins, both of which are published by H.M. Stationery Office, Adastral House, Kingsway, London, W.C.2:—

The Feeding of Dairy Cows.—Bulletin No. 42 of the Ministry of Agriculture and Fisheries, 1932 (price, 9d. net).

Rations for Live Stock.—Bulletin No. 48 of the Ministry of Agriculture and Fisheries, 1932 (price, 1/- net).

These bulletins give, in a concise and lucid manner, an account of the principles involved in feeding cattle and the method by which balanced and economical rations may be calculated for various classes of live stock.

It is not proposed to say much in this article of the theory involved, or of the methods of working out rations, since this information may be obtained from the bulletins mentioned above; more will be said of the practical application of rationing to the circumstances in force in the Trans Nzoia.

The Management of Grassland.

(*a*) *Indigenous Veldt Grass*.—Grass is the first and cheapest food of the dairy cow, and some mention must be made of the question of the improvement of grazing. It is evident that a cow that has its belly full of coarse grass, although it may have satisfied its appetite, will not have obtained sufficient digestible protein and starch equivalent to provide for several gallons of milk as well as for her maintenance requirements. Kenya figures are not available, but a number of analyses of East African grasses, made by French, have been published by the Tanganyika Department of Veterinary Science and Animal Husbandry. In default of digestibility coefficients for the various constituents it would only be possible to calculate the "starch equivalents" of these grasses very approximately, using European figures for the digestibility coefficients. Probably, however, the starch equivalent of average Kenya pasture may be assumed, for the sake of argument, to be 12.0 lb. per 100 lb. of green material, and the protein equivalent to be 2.4 lb.; in the dry season the figures are probably lower.

An animal which should weigh 9 cwt. if in condition requires 22 lb. of dry matter per day, and a maintenance ration of 6 lb. of starch equivalent, with 1½ lb. of digestible protein; the amount of energy wasted by walking about under the usual Kenya conditions probably raises these figures. 110 lb. of grass would supply the requisite dry matter, together with 13.2 lb. of starch equivalent and 2.64 lb. of digestible protein. A surplus of 7.2 lb. of starch equivalent and 1.14 lb. of protein equivalent would remain for purposes of production: 10 lb. of milk, of 3.9 to 4.0 per cent butterfat content, requires 2.60 lb. of "starch equivalent" and 0.63 lb. of "protein equivalent". It will be seen that the surplus starch equivalent would be enough for the production of two and three-quarter gallons of milk, but the protein would be adequate for only just under two gallons; it would therefore be necessary to give the cow some additional protein-rich food in order to enable her to produce three gallons; and she would require an extra balanced ration to produce over three gallons. In actual practice, the unsupplemented grazing may only suffice for the production of a gallon or a gallon-and-a-half of milk; the quality of the grazing is apt to be poorer in the dry season, while some loss of food value may be caused through the expenditure of an excessive amount of energy by the cow in her search for a sufficient amount of grass or, at some seasons, through loss of heat due to exposure to cold winds and rain. On the other hand, at other times of the year the grass may have a protein equivalent of about 3.6 lb., and may require balancing by the addition of more carbonaceous food, such as hay or crushed maize, when a yield of over three gallons of milk may be given with but small additional cost. It is well known that dairy cattle in Kenya often fall off badly in condition when they are feeding on the lush grass which is produced by the heavy early rains. Kikuyu grass, in particular, has a very laxative effect on the cows, and the animals should be given some hay, bran, or even a little cottonseed cake, to counteract the strong purgative action of the grass.

In general the feeding value of the grasses may be improved by the prevention of grass-burning and the substitution of paddocking followed by intensive rotational grazing. The use of artificial manures is still in the experimental stage, but the use of cheap rock phosphate would probably be advantageous in many

areas, especially in districts which are known to be phosphate-deficient.

(*b*) *Exotic Grasses and Grasses for Planting up Pastures on Arable Land.*—The trial of grasses and pasture legumes of native and exotic species was begun at Kitale by the Department of Agriculture in 1931. As a result of the work carried out during the last five years, a number of excellent grasses, both introduced and indigenous, are known which will serve for permanent or temporary leys. Future work on grasses must consist in tests designed to show the relative palatability, nutritive value and persistence under grazing of the various grasses, singly and in mixtures.

A large range of English pasture grasses have been tried, but these tend to wilt badly in the hot sun and to wither in the dry season. As regards the latter failing, however, it must be remembered that most of the indigenous grasses also are of little value in the dry season (with the exception of Red Oat grass, which is palatable and nutritious even when dry), and must be supplemented with other foods. The only English grass which seems worth continuing with is Cocksfoot (*Dactylis glomerata*), which makes prolific growth. Drought-resistant strains which might be selected of Crested Dogstail (*Cynosurus cristatus*) and Tall Oat grass (*Arrhenatherum avenaceum*) also are good. Nevertheless, the presence of so many good African grasses, or grasses from other sub-tropical regions, renders it unlikely that it is desirable to experiment much further with English grasses, unless it is shown that their nutritive qualities are far superior to those of the other grasses.

A few notes may be given on some of the grasses which may be planted from roots or from seed on arable land that is to be made into pasture in the Trans Nzoia or similar districts:—

Star Grasses (*Cynodon* sp.).—Palatable, nutritious and drought resistant. There are many different species or sub-species in the district.

Molasses Grass (*Melinis minutiflora*).—A very valuable grass for the Trans Nzoia and similar districts. It is palatable and is grazed very closely by the cattle. Fresh growth is made very rapidly after two or three inches of rain have fallen. It is very drought resistant.

Rhodes Grass (*Chloris gayana*).—Very common in the district and the indigenous strain is more vigorous than the Australian strain.

Kikuyu Grass (*Pennisetum clandestinum*).—While this grass does not make the same amount of growth as it does at higher altitudes and with a higher rainfall, it is well worth including in a mixed pasture. It requires conditions of high fertility, but it is unexpectedly drought resistant and is grazed eagerly by the cattle.

Paspalum scrobiculatum.—A useful and apparently palatable grass, which suffers at a certain time of the year from leaf-spots.

Red Oat Grass (*Themeda triandra*).—This grass is more suited to extensive grazing in dry areas and does not require high fertility. It is slow to make fresh growth after cutting or grazing, and would not be worth planting in paddocks, where, however, it would tend to enter naturally.

Numerous other indigenous grasses, such as *Setaria* sp. and *Brachiaria* sp., have good possibilities, and it is evident that there is great scope for improving

these species by selection of leafy or drought-resistant strains.

Amongst the imported grasses, *Paspalum dilatatum* is the most useful, being palatable and making vigorous growth. It resists the conditions of the Trans Nzoia dry season fairly well.

Introductions which have not lived up to their reputations for drought resistance and vigour in South Africa, Australia and Canada respectively are Woolly Finger grass (*Digitaria eriantha*), *Phalaris tuberosa,* and Crested Wheat grass (*Agropyron cristatum*).

Less success has been experienced with the trials of legumes. Clovers grow fairly well, but would doubtless prefer a more calcareous soil than the acid sandy soils of the Trans Nzoia. The clovers set seed well, and the production of seed for sale in Europe is a possibility which deserves investigation.

A great number of *Trifolium* sp. from all over the world have been obtained for trial during the last few years, and some of these may eventually prove to have their uses, particularly after re-selection of climatically adapted plants. At present the most promising legumes are Korean Lespedeza (*Lespedeza stipulacea*) and Kobe Lespedeza (*Lespedeza striata*). These Lespedezas may be seeded in old or new pastures, and re-seed themselves year after year. The perennial species, *Lespedeza sericea,* makes but poor growth. Birdsfoot Trefoil (*Lotus corniculatus*) is fairly successful, and Burr Clover (*Medicago denticulata*), though not yet tested in grazed pastures, has made such luxuriant growth in plots that it appears to offer hopeful prospects of being a very valuable pasture legume.

Before leaving the subject of grasses some brief mention must be made of management. Natural produce could be improved by degrees by the use of night *bomas* over the land, but this necessitates the feeding of hay or fodder crops to the cattle in these *bomas*, which would otherwise become over-grazed, while the cattle would lose flesh. Probably it will be found more satisfactory to plant up arable land with some of the desirable grasses which have been mentioned. It will be found that an acre of planted pasture on medium land in the Trans Nzoia will maintain one beast to the acre for seven or eight months between April and October; extra feeding or extra grazing will be needed during the dry season. The total acreage should be divided into five or six paddocks, which should be grazed in rotation. The milking cows should have access to the grazing first, and should be moved on after three or four days, being succeeded by the dry cows and young heifers. The grass should not be grazed shorter than about three inches or the hot sun will scorch the ground and grass roots; on the other hand, excessive growth in the rainy season should be kept under by means of the mowing-machine—which should also be used to cut grass flower stalks which have escaped the cattle—or by grazing off the grass rapidly with the work oxen. The aim in managing the grass is to graze it off rapidly and uniformly, and then to give it three or four weeks' rest. Over-grazing must be guarded against, and focal spots for erosion near the gates or near the water-holes or troughs must be dealt with by throwing down litter or rubble.

A great deal of moisture is lost, especially in the dry season, through hot dry winds. Effective windbreaks should be established, in order to reduce evaporation and transpiration, every 250 or 300 yards. It may be possible to use the outside row of trees of the windbreak as a

natural fence by fastening strands of wire from tree to tree or by nailing rails across.

There should also be sufficient shade trees in the paddocks for all the cattle to be able to shelter from the sun in the middle of the day.

Fodder Crops.

The ample rainfall of the Trans Nzoia makes it easy for a plentiful supply of fodder to be grown and stored as an insurance against a severe dry season.

(*a*) *Hay Crops.*—Teff grass (*Eragrostis abyssinica*) can be grown as a short-term rotation crop in districts such as the Trans Nzoia. Most farmers will be content, however, with the veldt grass, which, if treated properly, can be turned into hay which the cattle will eat with relish. It is desirable for the first cut of veldt grass to be made in June, and the cut for hay to be taken in September, when drier weather may permit of curing the hay fairly early. Cowpeas make a valuable legume hay, but are somewhat difficult to cure owing to the succulence of the stems. This crop may be grown successfully at altitudes of about 6,000 feet and lower where there is a rainfall of about 25 to 30 inches, or towards the end of the rainy season in wetter districts.

Edwards has pointed out the value of Rhodes grass as a hay crop in the November (1935) number of this Journal.

Lucerne hay is perhaps pre-eminent as a hay of high protein content. The varieties "Hairy Peruvian", "Provence" and "Early Hunter River" are chiefly in favour in Kenya, and are often grown under irrigation during the dry season. Lucerne hay should be dried in the shade on racks, as exposure to the sun has been proved to destroy 70 or 80 per cent of the vitamin content of the lucerne. Unfortunately, the rainfall of the Trans Nzoia in most parts is on the high side for successful cultivation of lucerne, which suffers from various leaf-spots and becomes defoliated.

The Soya bean, "Otootan", is capable of yielding a heavy bulk of forage in the Trans Nzoia, since the plant has a high dry matter content, but has not been grown extensively up to the present.

Guinea grass (*Panicum maximum*) and Keria grass (*Panicum coloratum*) are two useful hay grasses for the Trans Nzoia, though they have not yet been grown other than experimentally.

When the grazing is poor, a cow will probably need about 20 lb. of hay a day, but since hay and dry grazing is likely to have a constipating effect on the cows it is better for at least part of the hay ration to be replaced by succulent green food. It will be observed that an acre of grass, giving perhaps 25 cwt. of hay, would feed one cow on poor grazing for about 190 days, or a cow and a half for four months. Ideally, part of the ration should be composed of a legume hay and part of grass hay or maize silage, which latter foods are in themselves somewhat deficient in protein. A suitable ration in the dry season would be 8 lb. of lucerne or other legume hay and 5 lb. of grass hay plus 15 lb. of maize silage or as much silage as the cow would finish up in the day. In addition the cow would receive, on maize farms, 3 to 5 lb. of soaked crushed maize a day at milking-time.

(*b*) *Silage.*—Maize is supreme as a material for use in the preparation of silage in the maize-growing districts of the Colony. Maize silage is less fibrous and more palatable than sunflower silage and is more appreciated by the cattle than silage made from elephant grass, though the latter has the advantage that it does not require planting every year

and that several cuts may be taken in the year. The making of maize silage has been described in a previous article in this Journal, by French, and in Bulletin No. 26 of 1932 of the Kenya Department of Agriculture, and no further comment is necessary except to observe that it is good practice to cut the maize stalks into pieces about six inches or a foot long, prior to ensiling the maize, to facilitate tight packing of the material in the pit. A cow giving 10 to 16 lb. of milk a day will consume about 30 lb. of silage per day. This amount of silage will only contain about 5½ lb. of dry matter, whereas there would be about 25½ lb. of dry matter in 30 lb. of hay. Silage, like other odorous foods, should be fed in the field after milking in order to avoid tainting the milk. The same precaution should be adopted, incidentally, with regard to hay, owing to the risk of dust being blown into the milk.

Under Kenya conditions a yield of ten tons of maize silage should be easily obtained per acre where the rainfall is adequate for the crop. The cost of growing the maize up to the stage at which it is fit for cutting should not be much more than Sh. 7 per acre; cutting the stalks might be estimated to cost 25 cents an acre, and loading and carting Sh. 2/25 per acre; chaffing the stalks by hand would take approximately eight boy-days per acre at a cost of, say, Sh. 3; the filling of the pit, trampling of the silage, and the covering of the pit should not cost more than Sh. 2/50 an acre, giving a total cost of Sh. 15 per acre or per 10 tons of silage. This cost is equivalent to Sh. 1/50 a ton, in the pit, so that a ration of 30 lb. per head would cost two cents a day, plus the cost of removing from the pit, transport, and feeding to the cattle. This cost would be repaid by an increase of under 1/20th lb. of butter-fat, or 1 lb. of milk a day.

It is evident that all dairy farmers, in parts of Kenya where the climate and soil permit, should make a supply of maize silage each year. The farmer who has reserves of this valuable cattle food can face severe droughts with some equanimity.

(*c*) *Green Fodder.*—Elephant grass (*Pennisetum purpureum*) or "Napier's Fodder" (or, as it is often called in Kenya, Napier grass) grows successfully in most parts of Kenya except in the very dry areas and at the higher altitudes. In Trinidad, four three-monthly cuts gave a total annual yield of 42.7 tons per acre of green fodder, the value of which was roughly equivalent to "medium quality meadow hay ready for harvest". Previous work at the Imperial College of Tropical Agriculture, published in *Tropical Agriculture,* shows that a maintenance ration is supplied by 80 to 85 lb. of elephant grass. Unfortunately, the weight and class of animal receiving such a ration is not stated, but this amount of elephant grass would contain about 14 lb. of dry matter; the actual amount eaten in the trials was 114 lb. or 19 lb. dry matter, which is the English figure given for the appetite of an animal weighing 7 cwt., which happens to be about the weight of a good native cow in Kenya.

Since elephant grass is low in digestible protein, a suitable ration for a cow, on rough grazing, which is giving a gallon or a gallon and a half a day, would be 40 or 50 lb. of elephant grass plus a few pounds of legume hay. The safest course with such fodders is to feed as much as the animals will clear up, loss being minimised by placing the fodder in suitable racks in the field which allow sufficient "elbow room", to ensure that the stronger animals do not push out the weaker ones.

If the annual yield of elephant grass is put at the conservative figure of 25 tons an acre, then, at the rate of 50 lb. a day, one acre should provide fodder for 1,120 cow-days, or a dry-season cut of 6 tons would feed nine cows for a month. The fodder which grows in the wet season is not so urgently needed at the time, and can be preserved in the form of silage.

Apart from the expense of cutting and carting elephant grass fodder, the provision of this cattle food costs nothing beyond the initial establishment cost; once well established the grass will smother all weeds and will require no cleaning.

Other cheap fodder crops which may be grown for feeding cows are sweet potatoes—the haulm of which may be cut periodically — pumpkins, and edible canna. Pumpkins do best in the warmer parts of the country where the rainfall only amounts to 25 to 35 inches. Varied opinions are held as to the merits of edible canna, but this crop has its strong advocates amongst dairymen in some of the warmer, drier parts of the Colony. A certain reluctance, in the first place, on the part of dairy cows to eat edible canna may be overcome by chaffing the stalks together with some other material, such as lucerne hay or green fodder, until the animals have acquired a relish for this food.

In the drier areas, Sudan grass (*Andropogon sorghum* or *Sorghum sudanense*) has merits as a provider of forage or hay. This grass is able to cease growing in a droughty period and to resume growth with the renewal of the rains, without suffering damage.

Mangolds have been grown with fair success in the Trans Nzoia on a small scale, and may be fed in the dry season directly from the fields in which they are growing, and the stock eat these roots with great relish; whether it would be an economic proposition to grow these roots is somewhat doubtful. Mackintosh, referring to English conditions, says: "Whether roots should be grown or not is a question of the cost of production; if they can be grown at a cost per ton that does not exceed the price at which 2 cwt. of a cereal food such as rice meal can be purchased on the average of several years, they will be an economical and beneficial component of the ration; if the cost of production is materially higher than this, roots should not be grown." Translated into Kenya terms and allowing a modest yield of 15 tons per acre, this means that the cost per ton should not exceed that of 2 cwt. of maize, which is perhaps five shillings. While an acre of mangolds should not cost anything like seventy-five shillings to produce, it must be remembered that in many districts the roots would have to face the stern competition of elephant grass or maize silage, and there could be no question of which would be the cheaper. If maize silage could be produced for Sh. 1/50 a ton, before it paid to grow mangolds it would be necessary to produce the roots at about Sh. 1/20 a ton or Sh. 18 to Sh. 24 an acre, according to whether fifteen or twenty tons of the roots were produced per acre. It would be essential for the seed to be reasonably cheap.

Supplementary Feeding of Dairy Cows in the Trans Nzoia and Similar Districts.

(*a*) *The Native Cow.*—The question of native cow *versus* grade or pure-bred is a vexed one. In many instances, farmers begin their dairying experience with a mixed bunch of native heifers, since these may usually be bought cheaply, for forty to sixty shillings a head, whereas grade

or pure-bred cows will be far more expensive.

Some farmers also are not able immediately to afford a dipping tank, so they cannot risk the life of a pure-bred bull on their farm, though they hope to clean the grazing from East Coast fever by running immune stock over the land. They are prepared to run the risk of losing some of their calves from this disease, since the death of a native calf is not a great financial loss; it must be admitted that these farmers stand a grave risk of losing the majority of their herd within a few years, when most of the herd are susceptible to East Coast fever but are not dipped regularly.

The yield of milk of the Kenya native cow is usually low, though the butterfat content may be 5 per cent or more. Maize farmers, who are keeping cattle for the sake of making manure, may be content with small additional returns from cream for sale, together with a supply of milk, cream and butter for the house. The oxen reared find a fairly ready sale for work purposes, and several farmers run their cattle in night *bomas* over their fallowed maize fields in order to manure the land.

Compared with European breeds (*Bos taurus*), the native cow (*Bos indicus*) has exceptional powers of converting roughage into milk and of remaining in good condition even on relatively poor and apparently scanty grazing; thus, small returns from these cows may yet be profitable to their owner by virtue of the small costs of his overheads in his dairying enterprise and the small cost of production.

Other farmers may intend to "grade up" their herd later, by means of a pure-bred or high grade bull, or to select the better native cows for building up a native herd. That improvement of the zebu is not impossible is shown by several herds in India which average 500 or 600 gallons a year, while individual cows have given 700 or 800 gallons and more in a lactation. The results obtained at the Animal Husbandry Centres in this Colony, especially at Ngong and Baraton, also show substantial improvement in milk yields of local strains of zebus by selection, feeding and breeding. Individual native cows of merit may be found in Kenya (the writer bought casually a cow which gave 200 gallons in its first lactation and 300 gallons in its second lactation); however, the improvement of indigenous strains of cattle is generally a task for Government institutions or a hobby for those to whom the problem appeals, rather than a policy which can be generally recommended to the practical farmer.

Those who are interested in the improvement of native cattle would be advised to hand-rear the calves and to milk-record the cows. Cows falling below a certain minimum production—which should be progressively raised—should be culled, and the heifer calves and bulls kept only from high-yielding dams.

It will be found that immediate removal of the calf from a virgin heifer after birth will enable milking, without giving the heifer access to the calf, to be carried out as a rule with no difficulty. An important part of the procedure is "ante-natal care". The cow must be handled freely for several weeks before the calf is expected; the milk glands may be stimulated by massage of the udder, using some suitable lubricant, and the teats may be "milked out" for several weeks before the calf is due. Workers on the improvement of Indian zebus claim that great benefit has been derived in the succeeding lactation by this milking-out

before the calving date. This was done as often as twenty-three times a day, but, while this is not likely to be practicable, three or four times a day may be found possible by Kenya farmers.

Some farmers consider that it is beneficial to beat up a raw egg in the calf's early feeds of milk. If colostrum is available from another cow which has just calved down, this can be fed to a calf the mother of which has been milked out prior to the birth of the calf; in other cases, linseed oil may be given to the calf as a mild laxative.

Hand-rearing and the other practices will not be found such bugbears as is generally anticipated if a trained native can be obtained to supervise these tasks.

Unless they are unusually good, native cows can rarely be fed with concentrated foods as an economic practice, but must produce their milk on grazing and cheap fodder crops. Despite a high butterfat content of 5 per cent or over, the milk will probably be worth only about 30 cents (3½d.) a gallon on the farm (neglecting the value of the separated milk for calf-rearing), and only a small margin can be allowed for feeding expenses.

However, the practice of giving at milking-time a small allowance of coarse maize meal or well-kibbled (crushed) maize, soaked in water for several hours, can probably be defended. About 5 lb. of maize a day per head will keep the cows contented, it will help to balance the protein contained in green grass, and it will supplement the food value of the poorer grass of the dry season. This extra food only costs about seven and a half cents per head per day, with maize valued at Sh. 3 a bag of 200 lb. on the farm.

Apart from the utilization of a small quantity of maize, native cows should be able to provide their maximum yields on grass alone in the wet season, assuming that the pasture is not very poor or overgrazed, but the butterfat returns in the dry weather can only be maintained by means of feeding fodder crops. It is sometimes argued that it pays farmers in up-country areas that enjoy a long and almost continuous rainy season to arrange the calving-down of their cows so that the cows obtain all their food from the grazing and are "dry" during the dry season. This may be so where cream production is the only desideratum, but in most areas it is desirable to feed even the dry cows in the dry season, and the necessity to keep a cow in good condition prior to calving should not, but does, need emphasis; in more advanced dairying countries the practice of "steaming up" a cow before calving is usual in order that the cow shall give of her best in her approaching lactation. In any case, most dairy farmers in this country, especially those with native cows, know to their cost that calving dates cannot be arranged with mathematical precision owing to the difficulty which often occurs of getting the cow to "hold to the bull". It will be shown later that the expense of producing butterfat in the dry season on, for example, maize silage or elephant grass (*Pennisetum purpureum*) is very small, and even in the moist areas the benefit of receiving a cream cheque right through the dry season may appeal to many farmers. In the districts in which the rains fall at two definite periods in the year, it is obviously impossible to rely on the grass for any consecutive eight or ten months covered by a cow's lactation period, and, in order to increase the total income of the farm to a point at which a reasonable living is afforded to the farmer, supplementary feeding must be adopted. The delivery of cream to the creameries in fairly regular quantities throughout the year should enable the operation of the manufacturing processes

to be carried out more economically. Incidentally, it is doubtful if dairying will be financially successful in dry ranching areas—except in rare instances—in which it is impossible to raise forage crops.

(*b*) *The Grade Cow.*—Most farmers in the Trans Nzoia who intend to make the sale of cream a material part of their farming programme, and who have invested in a dip, will keep grade cows. As Ball has observed in a previous article in this series, it may be found economic to aim at a relatively low level of production, in which case the grade should not be too high. However, the calves should be hand-reared and the cows milk-recorded in order that poor yielders may be turned out of the herd. The higher the grade the poorer will usually be the capacity of the animals for making use of food of inferior quality or of a fibrous nature; at the same time, the animals will have larger frames and consequently bigger appetites. Any farmer who keeps grade cows should, as a matter of course, paddock his grazing and endeavour to improve it. The supplementary feeding of these cows also should be carried out as far as possible with fodder crops, particular attention being given to the provision of the palatable succulent foods which will annul the constipating effect of the dry, fibrous pasture which is grazed by the cattle in the dry season. A cow's appetite is limited, however, and it may be found necessary and economic to feed some cheap home-grown or locally produced concentrates to the higher-yielding cows. The feeding of concentrated foods will be chiefly necessary in the dry season, when the grass has fallen off in quality and quantity; even then it will probably only be necessary to feed concenrates to animals giving over one and a half or two gallons a day. The grazing plus bulky fodder crops should provide for the maintenance requirements and the first gallon or so of milk. It must be remembered that feeding the "maintenance requirement" entails keeping the animal in reasonably good condition. An animal which has the potentialities of a good milker may continue, without extra feeding, to give two gallons or more of milk a day at the expense of her appearance. A farmer who takes a pride in his animals will wish to see them with sleek and glossy hides, without their being over-fat; only by adequate feeding will a cow be induced to prolong her lactation and give the maximum yield of which she is capable within the lactation period.

The basal yield of milk given on grazing and fodder is that which normally carries the overhead charges of the farm; any yield given above that may be considered to carry only the cost of the extra ration and the expense of the extra milking and handling. Thus it is profitable to produce the extra yield of milk, and so to increase the general turnover of the farm, if the additional gallons can be produced for materially less than 25 cents per gallon; this should not be difficult where a substantial part of the ration of concentrates consists of home-grown foodstuffs. Nevertheless, it must be borne in mind that any feeding which is carried out must bear a strict relationship to the recorded milk yield of the individual animals, and must show itself to be justified financially by the extra return. Fodder crops are comparatively cheap to produce, but the wise farmer will keep a watchful eye on the expenditure on concentrates and will examine the milk records of individual cows every fortnight in order to adjust the rations, up or down, as may be necessary.

East African farmers enjoy the advantage of there being certain locally produced concentrates which can be bought far more cheaply than these foods can be obtained in most dairying countries. Some of these foods are: Maize meal, maize, simsim cake, linseed cake, pollards, bran, cotton-seed cake, groundnut cake, barley meal.

There seems no reason why decorticated cotton-seed cake—a palatable feed in which the digestible pure protein content amounts to about 34.6 per cent—should not be manufactured in Kenya or Uganda and sold at a cheap rate to stock farmers. This cake is valuable as a preventive of scouring. The undecorticated cotton cake has an objectionably high fibre content of over 20 per cent, and is very constipating; its feeding value is not greater than that of good hay. Both simsim (sesame) cake and groundnut cake of East African origin have contents of pure digestible protein, on a dry matter basis, of over 40 per cent.

A feeding test carried out by the Rowett Research Institute, with small numbers of cows at Doonholm, Athi Plains, in 1927-28, gave increases in milk yields of 105 and 77 per cent respectively. Both trials were conducted during periods of drought, and in the second trial, in which eight cows were used for the experimental feeding and eight cows for the control, an increase of 1,189 lb. of milk resulted from feeding 800 lb. of simsim cake at Sh. 6 per cwt.; this is equal to a cost of 36 cents per gallon, and would only be economic if the milk was intended for sale as whole milk and not merely produced for butterfat.

It will be evident from the foregoing that considerable caution is necessary in the feeding of concentrates. A mixed ration, containing more than one kind of protein-rich food, is generally desirable on grounds of greater palatability, and the laxative or astringent properties of various foods may neutralize one another. Obviously it is impossible to dogmatize as to which are the cheapest rations of concentrates, since this will depend upon which foods are available on the farm, the distance from rail, and other factors, but a few typical rations—to produce one gallon of milk—are appended:—

Rations (to produce milk with about 5 per cent butterfat) containing approximately 3 lb. of starch equivalent to 0.74 lb. protein.

		lb.
1.	Linseed cake	1
	Simsim cake	$\frac{1}{3}$
	Maize meal or kibbled maize ...	$2\frac{2}{3}$
		4

		lb.
2.	Linseed cake	1
	Crushed oats	1
	Kibbled maize	1
	Simsim cake	1
		4

		lb.
3.	Simsim cake	1
	Rice dust	1
	Linseed cake	2
		4

		lb.
4.	Pollards	1
	Simsim cake	$1\frac{1}{2}$
	Kibbled maize or posho	$1\frac{1}{2}$
		4

		lb.
5.	Bran	$\frac{1}{2}$
	Linseed cake	$1\frac{1}{2}$
	Maize	$1\frac{1}{2}$
	Simsim	$\frac{1}{2}$
		4

Rations (to produce milk with about 3.7 to 3.8 per cent butterfat) containing 2.5 lb. starch equivalent and 0.6 lb. protein equivalent.

	lb.
1. Linseed cake	1
Simsim cake	1
Maize meal or kibbled maize ...	1½
	3½

	lb.
2. Linseed cake	½
Crushed oats	1
Kibbled maize	1
Simsim cake	1
	3½

	lb.
3. Simsim cake	1
Rice dust	1½
Linseed cake	1
	3½

	lb.
4. Pollards	1
Simsim cake	1
Kibbled maize or posho	1½
	3½

	lb.
5. Bran	½
Linseed cake	1
Maize	1
Simsim cake	1
	3½

	lb.
6. Simsim cake	1
Bran	1
Maize	1½
	3½

	lb.
7. Simsim cake	1
Maize	1¼
Rice dust	1
	3¼

Note.—Decorticated groundnut cake could be used to substitute simsim cake, in whole or in part, in the above rations.

Minerals.

Feeding experiments carried out with milch cows at Molo (reported upon by the Rowett Research Institute) showed that the use of appropriate mineral supplements resulted in an increase of about 30 per cent in the yield during a complete lactation. Although such an excellent return could not be expected in all areas, the feeding of minerals should be a standard practice. It is not possible to suggest a balanced mineral lick that will be equally economical and suitable in all districts, since the extra mineral requirements of the cattle will be determined by the mineral content of the soil and of the grasses and fodder crops and concentrates which are eaten. Leguminous plants are particularly efficient in absorbing calcium and phosphates from the soil and so cattle that are grazing on pastures containing leguminous plants or that are feeding on legume hay will have less need for supplementary minerals. Usually cattle in the Trans Nzoia seem most avid for salt; this is not surprising when it is stated that, under English conditions, the daily allowance should be at the rate of 1 oz. per head, plus about ½ oz. for each gallon of milk produced. In addition, a European cow of average weight is stated to need 1½ oz. lime (CaO) and 4/5th oz. phosphoric acid (P_2O_5) daily for maintenance; for production per gallon of milk, ½ to ¾ oz. lime and ⅔ to 1 oz. phosphoric acid. There is much to be said for placing the minerals in separate boxes, and letting the cattle help themselves on the "free choice" system.

Sterilized bone-flour should be available and also ground limestone. Theft of cattle salt by natives is a source of expense which must be guarded against.

This may be avoided, as far as theft for human use is concerned, by mixing the salt with equal parts of ground limestone or by mixing the salt with Kerol.

Water Supplies.

A cow is stated to need five gallons of water daily, plus three gallons for every gallon of milk produced. These figures, which refer to English conditions, are probably on the low side for many parts of Kenya, and the importance in dairy farming of securing a readily accessible and ample supply of sweet drinking water for the cattle can hardly be overemphasized. At the same time, it is realized that this question of water supply is a major problem to many dairy farmers. No section of the community should be more interested than dairy farmers in the protection of the water supplies of the Colony by prevention of deforestation of catchment areas and the pollution and obstruction of stream flow through the erosion of denuded land and consequent deposition of silt. A continued increase in the amount of dam-building or the sinking of bore-holes is essential for the progress or continuance of the dairy industry in some districts which are ill-provided with springs and streams. Wherever possible, watering places should be protected from becoming muddy quagmires, through trampling by the cattle, by revetting the bank and preparing a platform of rock or concrete on which the cattle may stand without churning up the water in the stream or water-hole into liquid mud. The tracks down to the stream or dam should be stepped down with rock or baulks of timber.

Summary.

An ecological and agricultural review of the Trans Nzoia has been made from the point of view of arable dairying. The value of the natural veldt grass has been discussed, and mention made of the trials of grass and of legume species which have been carried out by the Department of Agriculture at Kitale during the last five years; a few notes are given on the method of grassland improvement which should be adopted in the district.

The production and feeding of fodder crops has been discussed. Finally, the feeding and management of native and grade cows in the Trans Nzoia has been described, an account given of suitable rations for special feeding of concentrates, and mention made of the question of mineral supplements and water supplies.

Acknowledgments are made to the Forestry Department, Nairobi, for kindly supplying the botanical names of the trees of the Trans Nzoia savanna country.

Soil Erosion: A Simple Home-made Level for Obtaining the Line of Contour Banks

Department of Agriculture, Kenya.

It is not easy to set out contour lines by eye without the assistance of some instrument. It is probable that native agriculturists, who are in the habit of constructing bench terraces on steep hill-sides, develop some considerable accuracy in marking out their terraces through constant practice. Natives who are not traditionally accustomed to constructing level terraces are likely to experience much difficulty however; there is a natural tendency to work gradually downhill, and bench terraces running off the true contour will concentrate run-off and lead to gully erosion. A simple home-made level is described in the *New South Wales Agricultural Gazette* for July, 1934, which might be of value for natives who are constructing bench terraces or level contour banks; the level might also be helpful to coffee planters who are making narrow-base contour terraces, especially since the instrument described could be used by two or three intelligent natives with very little supervision. Level contour banks are also of utility on pasture land for the prevention of erosion, and the home-made "level" might be used on pastures, both in European and native areas, as in New South Wales.

Construction of Home-made Level.

The following description is abstracted from an article entitled "Soil Erosion", by E. S. Clayton and John L. Green, in the above periodical:—

"The materials required are:—

One piece of light timber, 12 ft. 6 in. long by 4 in. x $1\frac{1}{4}$ in. or 3 in. x 2 in.
Three pieces of timber 8 ft. long by 4 in. x $1\frac{1}{4}$ in. or 3 in. x $1\frac{1}{2}$ in.
One carpenter's level.
One saw.
20 ft. of string.
Hammer and nails.

A level or even piece of ground is selected and the string stretched between two pegs about 18 ft. apart. Next, two 8 ft. pieces of timber are placed with one end of each near either peg. The 12 ft. 6 in. and the other 8 ft. piece of timber are then placed parallel, as they appear on the diagram. A length of 16 ft. 8 in. is measured along the string and marked. Each leg of the 'level' is then moved so as to space them exactly this distance apart at the base.

The 8 ft. piece of timber is then nailed on as a stay piece, the top edge being placed 4 ft. 7 in. above the string, to which of course it will be parallel. Next, the 12 ft. 6 in. piece of timber which is to carry the level is nailed on exactly 2 ft. 4 in. above and parallel to the base line. Particular care must be taken to see that this piece of timber runs parallel to the string. Next mark each leg where the string passes over it, then nail or bolt together, after checking all the measurements again. The carpenter's level is then mounted on the 12 ft. 6 in. piece. Mark and cut off the ends with the saw, as indicated in the diagram."

The level so constructed would be a true level. For some purposes it is desirable for a gentle fall to be given to the contour bank, though bench terraces should be exactly level. A fall of 1 in 200 could be given by the sawing off of 1 inch from one of the legs. The longer leg, which could be marked, in this case would always be placed downhill, since the fall is from the shorter or upper leg towards the longer leg. In general, however, it will be found better to use a level which will set out a line on the exact contour.

Pegging the Contour Lines.

A short peg should be driven into the ground at the point of commencement, and as the level is moved across the field other pegs are driven in where the forward leg touches the ground each time. Two natives will be required for this work.

Spacing of Contour Banks.

The spacing of bench terraces will depend upon the width of the bench terrace required and upon the amount of labour which will be necessary to form the terraces with a reasonable expenditure of effort. The spacings for narrow-base terrace *banks*, which should be about 3 ft. wide and 18 in. to 2 ft. high, may be taken for slopes up to 10 per cent from the following table, which is reprinted from Bulletin No. 1 of 1935 of the Kenya Department of Agriculture:

Slope of Land per 100 feet	Distances Between Terraces Down Slope
Less than 1 foot ..	200 feet
1 foot	200 „
2 feet	125 „
4 „	75 „
6 „	58 „
8 „	50 „
10 „	45 „

For more severe slopes the distances apart must be worked out from experience of the various soil types. Slopes which are as much as 20 per cent or more will probably need banks as close as 25 or 30 feet apart. It is very important that the narrow-base terrace banks should not be spaced too far apart on a sharp slope or the accumulation of water behind one terrace may overflow and cause a gully right down the hill. In coffee plantations, box terracing, described in Kenya Bulletin No. 1 of 1935 ("Soil Erosion," by V. A. Beckley), will assist in preventing such an accumulation of water and the wash from terrace to terrace. The fall of a slope may be ascertained with this home-made level by taking six measurements in the direction of the most severe slope, raising the lower leg each time until the carpenter's level shows that the crosspiece is level, and measuring with a graduated rod or tape measure the distance from the ground to the bottom of the lower leg. The summation of these six measurements will give the total fall in a hundred feet down the hill, that is to say, the percentage slope.

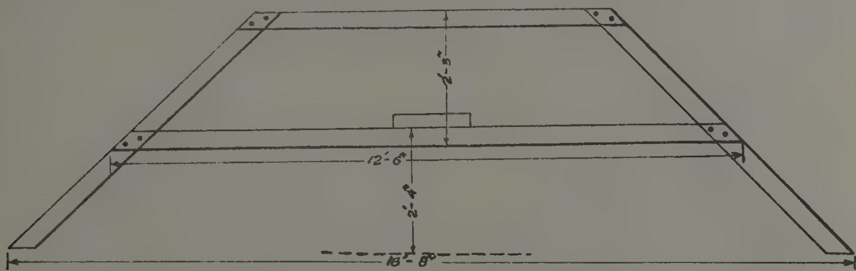

Diagram of Home-made "Level" for Locating Line of Contour Banks

Construction of Terraces.

Bench terracing is very expensive in labour, and usually is only employed in native agriculture or for such high-priced crops as vines. Where possible, the edges of bench terraces should be supported by stone walls and cross walls made across. The cross walls will be of value in checking any wash which tends to occur along the terrace bed owing to a slight error in grading. Narrow-base contour ridges in coffee plantations will, of course, be made by hand, but the cost should not be excessive, probably being in the neighbourhood of Sh. 1 per acre. Narrow or broad

(*Continued on page* 76)

Memorandum on Coffee Research and Experimentation

By S. M. GILBERT, *B.Sc., N.D.A., Chief Scientific Officer, Coffee Research Station, Lyamungo, Tanganyika.*

Field experimentation has made great advances during the last ten years. With the first appearance of Fisher's book, *Statistical Methods for Research Workers*, in 1925, his methods have been increasingly applied, more quickly in annuals as being simpler.

The method embraces three principles which are essential to the modern design of experiments: —

(i) Replication, which increases the precision of the experiment, and provides an estimate of error.

(ii) Randomization, which enables comparisons to be made of different treatments on different plots.

(iii) Localization of control, which eliminates soil differences in the field, and, by the analysis of variance, removes them from the estimate of error.

With perennials there are great initial difficulties, such as—

(i) the length of life of the plant;

(ii) the variability in the characters of the seedling material, which is often the only type available.

Even in temperate zones it is recognized that the old type of experiment is valueless.

In Technical Communication No. 2 of the Imperial Bureau of Fruit Production,* to whom acknowledgment is made, it is stated as follows: —

"These earlier workers, however, soon found that experiments with fruit trees 'exhibit errors from sources which do not generally affect experiments in agriculture', and it soon became apparent that both the material which they used and their methods of experimentation would need great improvement if such experiments were to be of any practical value. Thus Chandler, one of the foremost of American workers, emphasizes the fact that such field experiments 'have not yielded as valuable results as was expected of them'. This he attributes to the high variation, and notes that 'experimental results have been published in which the yield of the treated plots was nearly twice that of the untreated plots and yet it was not certain that the difference was due to the treatment'.

Workers at the Geneva and Pennsylvania Stations also deplore the meagreness of the results of a period covering some 30 years of fertilizer experiments.

Why have these early trials failed to yield information and what are the causes of the larger errors to which they were subjected?

Field experiments are subject to error from two main sources: (i) the inherent variation in the material which is being dealt with, and (ii) the variation which is due to outside factors reacting on the plant after the experiment has been planted up."

The following is a further extract from the above publication, and sets out clearly the difficulties in the way of field experimentation from an authoritative source: —

"*Field Experiment with Permanent Crops in Tropical and Sub-tropical Countries.*

Whatever opinions they may hold as to the merits of Fisher's methods for application in the tropics, research workers there are admittedly confronted with difficulties peculiar to their situation and to the crops with which they have to deal. These difficulties will now be briefly considered. . . .

a. In this sub-group [i.e. crops which are cross-fertilized and heterozygous, and which are capable of being reproduced by vegetative means] are found such important crops as cacao, citrus fruits, rubber and cinchona, which can all be propagated by budding or

* *Field Experiments in Horticulture*, by T. N. Hoblyn, Dip. Hort. (Statistician, East Malling Research Station, Kent), 1931.

grafting, and tea, dates, bananas, pineapples, and tapioca, which are usually propagated from cuttings, slips or suckers. Rubber, cinchona, tea and tapioca are included as being subject to much the same rules of experimentation as trees cultivated for their fruit.

In this class, by far the most important problems at present are those which concern the standardization of the material with which experiments are to be carried out. Cheesman says of ordinary plantation cacao, that at the present time it is a seedling crop exhibiting a range of variability probably at least as wide as that covering all the existing horticultural varieties of apples.

These remarks apply equally to the vast majority of crops in this class, as grown to-day. Citrus fruits, indeed, have advanced one step further and definite varieties are known and propagated by budding on to seedling rootstocks; but as long as this unknown factor of the seedling stock is allowed to remain, with the possible exception of the West Indian lime, which is said to breed true from seed, even this large class of fruit trees will not be a really satisfactory crop for field experiment.

An interesting possibility in connection with citrus fruits is the utilization of the phenomenon of polyembryony—a common occurrence in this class of fruit trees. By this means it may be possible to raise vegetative families from seed, as long as the sexual embryos can be recognized soon after germination and removed. These possibilities are already being explored.

The process of standardization has also already begun with cacao and rubber, and clonal varieties are being established and propagated by budding. That the standardization of the scion varieties is only the first step on a long journey has, however, already been shown by Harland who, referring to cacao, says: 'There is no method of telling whether a tree will transmit heavy yield either to its budded or seedling offspring except by testing it.' The next step is once more the elimination of the seedling stock, and research work having this end in view has already been started. . . .

b. The standardization of such material must necessarily be a much longer and more uncertain process than where vegetative propagation is possible. Already breeding work and selection of seed from heavy bearing parents have been started, but it will be a long time before really uniform trees are a practical possibility.

In addition to variable material, tropical workers have to face many difficulties which are not usually met with in temperate countries. These include aspect, gradient, the necessity for shade trees, artificial means which have to be adopted to check erosion, such as silt pits, contour drains, terraces and contour hedge crops. Again the necessity for following the contours on steep lands to prevent erosion increases the difficulties of spacing and plot arrangement.

Experimentation with Variable Material.

In the meantime, until these various processes of standardization are accomplished, and in the face of these difficulties, are field experiments with such variable material worth while?

The answer to this question is most definitely, Yes—provided the experimenter is prepared to take enormous trouble to get his results and refuses to be hurried. But if such conditions cannot be fulfilled, then, in the writer's opinion, the experimenter would be better advised to postpone the elucidation of such questions as pruning, manuring, and cultivation, and concentrate on the task of standardization.

The importance of individual tree records with deciduous crops has already been stressed. With such variable tropical crops as are now under consideration it is the only possible way to get reliable results. In such experiments every tree is a separate entity, and such a quality as a heavy or light bearing capacity is only one of the many ways in which it may differ from its neighbour. The only way therefore in which a general answer can be obtained to such a question as the effect of a particular fertilizer upon cacao is by observing the effect of that manure upon a large number of individuals and comparing their performance with that of an equally large number of individuals from which that fertilizer has been withheld.

This information can be obtained with greater accuracy and with fewer trees in some cases, if the performance of the trees is known for some years before the differential treatments are begun. On the River Estate, Trinidad, large numbers of cacao trees have been

recorded for a ten-year period, and it has been definitely shown that heavy bearing trees as a rule remain heavy bearers and light bearing trees remain poor croppers.

This fact is said to be true for several other crops, including coco-nuts and oil palms, but a word of warning would seem to be necessary here.

Such a record, if it is to be of any value, must be kept for a sufficient number of years, and the bearing capacity of young trees should not be taken as a criterion of their future performance, e.g. coco-nuts cannot be considered mature until five years after the plantation has come into full bearing.

Basing his deductions on the yields of cacao recorded on the River Estate, Freeman considers two years' record the minimum period, provided the cropping is undisturbed, but other workers have, in conversation with the writer, suggested a considerably longer period than this.

With regard to coco-nuts, it must be remembered that most plantations are uncultivated, and the mere fact of bringing a plantation into cultivation for the purpose of a manurial trial will have a considerable effect on the trees. This crop then should be cultivated and recorded for at least five years before the manures are applied. With apple trees it is a characteristic of certain combinations of scion and rootstock that they start to bear heavily early in life, while others do not readily reach their full bearing capacity until more than ten years old. There seems every possibility that the same phenomenon may be apparent in the heterogenous collections of seedlings or clonal varieties on seedling stocks at present under consideration. Thus in the case of the oil palms previously referred to, though the correlation between successive years' yield in the 5th, 6th and 7th years was always positive, it was not until the eighth season that the yield was very highly correlated with that of the previous year.

The problem of arranging such experiments is rather complicated. If the variation is not very high except in yield, ordinary randomized blocks may be used, and the data analysed, not on the basis of actual yield, but taking as the variable the rate of increase over the previous record of the tree. Lord and Abeyesundera have used what they term the 'Percentage Increase' method for plots of rubber trees (calculating the percentage increase of each plot over the previous year's yield), and have obtained thereby seemingly very accurate results.

They recommend the use of 24 tree plots replicated in randomized blocks, laying down quite rightly that this percentage increase method is of no use without replication. The writer, however, will go further in saying that with seedling trees, even though, as in this case, they may have one parent in common, the method may prove definitely misleading unless the variation of individuals is taken into account.

The high variation in young rubber trees at the Rubber Research Institute of Malaya, shown by Haines, further enforces this argument.

This worker has laid out a large scale manuring experiment on rubber trees, using the latin square method of arrangement, and plots of 81 trees surrounded by a guard row.

In a recent paper he suggests that 'plots should be adjusted to the natural unit for estate recording,' but for trials other than manurial trials individual tree records are recommended.

The use of randomized blocks for individual tree plots is apt to entail difficulties, as will be shown in the third example in this paper, for though such a method may be suitable for such management experiments as pruning, for manurial, shading, spacing or cultivation trials larger plots are necessary.

It seems therefore that the only possible way to get satisfactory results is to use comparatively large plots such as these workers suggest, and to consider not only the variation between plots but also that within plots by taking individual tree records.

Another difficulty which may make the ordinary use of randomized blocks or the latin square of little value is the nature of the soil heterogeneity. Martin and Beckett, in a recent paper, say of West African conditions: 'In our experiments we are not concerned with major soil differences such as those due to different soil formations, but to minor differences due to causes such as previous cultivations, positions of ant-hills, dung-heaps and minor differences of level and drainage.'

In Ceylon again, experimental work has to be done on ground of all levels which has been cultivated in very small holdings for generations.

For such cases, Martin and Beckett have suggested a modification of the randomized block method, when treating trees of known history, by which the blocks are allotted, not to different positions of the ground, but to differences in yield capacity. Thus the trees are grouped in categories according to their previous yields, and a block containing each treatment at random is allotted to each category. This method involves, of course, individual tree plots.

The necessity for guard rows is mentioned in other parts of this paper. With tropical crops these are no less essential, and if possible some tree of uniform size and root range should be used. This applies especially to experiments involving such crops as coco-nuts and rubber, where the root range is very great. Sampson has shown that where manure was applied to a strip of 8 feet down the centre of the middle of five rows of coco-nut palms, while the row which received the manure gave the largest increase in yield, both those immediately adjoining it gave a very appreciable increase also.

The possibility of utilizing shade trees in the guard rows, especially where shade is not the immediate object of the trial, is worth consideration.

Finally, it must be repeated that a field experiment with a heterogeneous crop is a complicated and precarious business, calling for the utmost care and patience. There are, however, definite signs that standardization of material, with many of the major tropical and sub-tropical crops, will, in time, become an accomplished fact. The growing appreciation that it is the most vital necessity for the improvement of these crops gives definite hope for the future."

To summarize, it is recognized now almost universally that certain data must be accumulated regarding tropical perennials before precise field experiments can be successfully carried out.

That planters see this is shown by the fact that such investigations have been carried out mainly at crop stations supported almost entirely by the planters themselves, such as the Rubber and Coco-nut Research Stations of Ceylon and Malaya.

The most important data required are:—

(i) Individual tree records,

(ii) Uniformity trials,

(iii) Knowledge of plot size,

and, for precise work, standardized material.

Up to 1934, little had been done in the study of these factors in *C. arabica*. Even at this time many planters in East Africa are unaware of the lines of successful progress in other crops, and fail to realize the vital necessity for such work on coffee.

Fortunately, however, with the inception of the Coffee Research and Experiment Station, Lyamungo, Tanganyika Territory, this need was recognized and was made a fundamental basis on which to build up an experimental programme.

At this date the station is in possession of individual tree records of some 10,000 trees, in blocks of 7-800, for a period of two years. The recording continues.

The figures show that the variability in yield and growth is as great as that for any tropical perennials yet recorded and, moreover, is accompanied by very pronounced biennial bearing.

The data are sufficient to justify field experiments on certain of the more uniform blocks, provided each experiment is repeated in several localities and over several seasons.

Knowledge as to plot size has also been obtained.

For precise work considerable advances in the standardization of planting material have been made. Such material will be available in considerable quantity in 1937.

Virus Diseases of East African Plants:

VI.—A Progress Report on Studies of the Disease of Cassava

By H. H. Story, *M.A., Ph.D., Plant Pathologist, East African Agricultural Research Station, Amani, Tanganyika Territory.*

A study of the virus diseases of cassava is now in progress at Amani. Although the work is far from being completed, it appears advisable at this stage to place on record some conclusions that have been reached and to indicate some of the directions in which research is leading.

It has become obvious that the problem of cassava virus diseases is much more complicated than has hitherto been recognized. In the past, mosaic (the *Kräuselkrankheit* of the early German workers at Amani) has been regarded as a single entity. It now seems certain that several distinct viruses have been included under this one heading. In addition, a virus producing a different type of symptom, to which the name "brown streak" has been tentatively given, has recently been recognized.

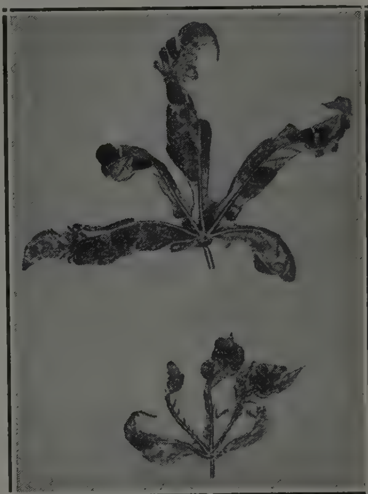

Fig. 1
A severe strain of the mosaic virus. The typical pattern produced, with yellow and green areas and severe distortion.

The Mosaic Groups.

A collection of mosaic types, selected in the field near Amani, has been made. The virus from each type has been transferred to plants of a single variety, and by growing these plants alongside under similar conditions, an attempt has been made to detect consistent differences in the symptoms produced.

The result has been to separate the local strains of virus into two groups. One group, which I class as "severe", produces a well-marked mosaic pattern, with pale yellow chlorotic areas and severe stunting and distortion (Figs. 1 and 2). The second group of viruses is altogether less severe in its effects; the pattern is ill-defined, the chlorotic areas are not yellow but only a somewhat paler

Fig. 2
A severe strain of the mosaic virus, producing a markedly localised effect. Two leaflets are severely affected and resemble those shown in Fig. 1; the two other leaflets are predominantly normal, with only small yellow areas.

shade of green than normal, and distortion is slight or absent. The illustration in Fig. 3 is of a leaf showing these symptoms unusually strongly. Often some leaves of an affected plant may appear entirely normal.

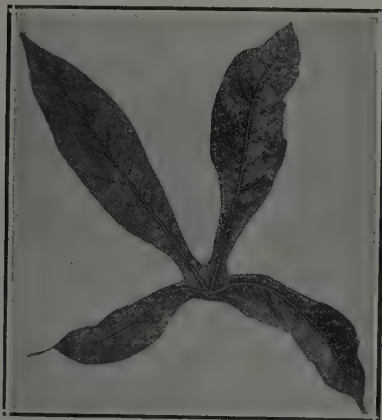

FIG. 3

A mild strain of the mosaic virus. The pattern is produced by pale green and dark green areas. This leaf was chosen as showing the effect more markedly than is usual with this virus. Usually the pattern is very faint and distortion is almost absent.

These are indications that, within each group, strains showing consistent small differences from one another may occur. At present this point is not certainly established; and it is doubtful whether any purpose would be served by an attempt to carry differentiation beyond the groups. The differentiation into the two groups is, however, fully established and free from all uncertainty.

It is doubtful whether the viruses in the two groups may correctly be regarded as all strains of a single virus. Experimental evidence of transmission by white fly (*Bemisia* sp.) has been obtained for severe strains only, and it is at present uncertain whether this insect is also the vector of the mild strains. Furthermore, I have found that the mild strains fail to confer immunity from severe strains; this evidence rather suggests that the two groups are not related.

The preceding conclusions are based on the study of viruses that occur in the Amani district. It is probable that elsewhere there occur different viruses or virus strains. Cassava varieties that are highly resistant in West Africa have proved to be highly susceptible in East Africa. The conclusion that I draw from this evidence is that the viruses in West African strains are different, at least from the severe group in East Africa.

In East Africa the group of severe strain is alone of economic importance. Their ill-effects on the yield are almost always serious, though varying widely according to the variety and the stage at which infection occurred. The effects of the mild group are probably very small.

THE BROWN STREAK VIRUS.

The disease produced by this virus has been known for several years in the Amani district, but only during the past year has it been recognized as distinct from mosaic. Evidence of grafting experiments has shown that it is a transmissible systemic disease; it may occur in a plant free from any mosaic virus, or in one mosaic-diseased, in which case the plant shows the symptoms of both diseases independently (Fig. 6).

The brown streak virus produces two types of symptoms. Firstly, dark brown circular or elongated lesions are visible on the young green stem (Fig. 4). As the stem barks over, the lesions remain as more or less sunken areas, so that the old stem is misshapen and the bark is cracked. Secondly, the older leaves develop, after they have matured, a somewhat diffuse mottling of yellow areas,

tending to follow the smaller veins (Fig. 5). This mottling is of a different character from the mosaic pattern (Fig. 6); furthermore, it is distinguished from

Fig. 4
The brown streak virus. Typical brown lesions produced on the young stem.

mosaic by the character that, whereas in mosaic the pattern is present on the young leaf as it opens, in brown streak disease the mottling develops only later on leaves that were quite normal when young. The mottled leaves are free from the distortion usual with mosaic.

In a severely affected plant the stems become brittle and may break off at ground level, leaving only a bare stump in the ground. The tuberous roots, if any are formed, have brown lesions similar to those on the stem. Thus the disease may result in a complete loss of crop. Such severe manifestation is encountered, however, only under relatively low temperature conditions, such as those met during the winter at the altitude of Amani. At higher temperatures the virus appears less able to exert its effect, and the symptoms may be largely suppressed. This is particularly true of the stem-lesion condition. Plants, which during the winter were leafless stumps, put out new strong shoots when the temperature rose. The leaves of these shoots, however, showed the characteristic mottling, although few stem lesions were to be seen. Thus the disease, although liable to be extremely severe at high altitudes, is of less importance under conditions most favourable to the growth of cassava.

The identity of the insect-vector has not yet been determined.

Brown streak disease appears to be widespread in East Africa, although possibly not so universally distributed as mosaic.

Control.

It is a universal rule that viruses are transmitted through vegetative propagation. Cuttings from a diseased cassava plant will always produce diseased plants, and, as the most severe ill-effects follow from this primary type of infection, losses would be in a large measure avoided if selection of healthy planting material were regularly carried out. Such selection is by no means easy in many parts of East Africa. Existing plots of cassava are often so extensively diseased that healthy plants are hard to find; and often apparently disease-free plants may carry the

disease in a latent form, and their progeny will be diseased. Where infection is not so extensive, considerable benefit would follow from teaching the grower to select healthy cuttings. Elsewhere the only possible course appears to be to establish special plots of healthy plants and roguing facilitated. There is a chance that a plot in an isolated site at low altitude, distant from any diseased cassava, might in a similar manner be maintained disease-free. If action were taken upon these lines, an organization would be necessary both for the distri-

Fig. 5

The brown streak virus. The somewhat diffuse mottling of yellow and green produced on old leaves of an affected plant.

for later distribution. Fortunately, the insect-vector of severe mosaic strains is for some reason less active at high altitudes, so that, at Amani for instance (3,000 feet), it is perfectly feasible, in so far as mosaic is concerned, to establish healthy plots and to maintain them, by inspection and roguing, practically disease-free. At present we cannot say whether the spread of brown streak would be similarly checked; but at least at high altitudes diagnosis would be easy

bution of cuttings to growers and for the continued maintenance of the supply-plots; for periodical replacement of planting material would need to continue indefinitely. We may note, however, that the advantage of this procedure appears to be already appreciated by natives in the Morogoro district, who regularly obtain planting material from the mountains.

From every point of view, it would be advantageous if, instead of complicated

and only partially successful direct measures, we could control the diseases by the use of resistant varieties. There is great need for extensive research by a plant-breeder. The problem is a large one, for not only is resistance against two viruses at least to be sought, but the varieties selected must be suited to a range of climatic conditions and to differing tastes and demands of the growers.

Fig. 6

Mosaic and brown streak viruses together. A leaf showing (a) localised mosaic pattern similar to that in Fig. 2, and (b) an early stage in the development of the mottling due to the brown streak virus.

The terms used in discussion of this subject require definition, for much confusion has arisen in the past by their use in different connotations. I would recommend that "resistance" be used in relation to liability to contract infection; that is, under equal conditions, a plant of high resistance contracts the disease less freely than one of low resistance. At one end of the scale we have "immunity", which implies a complete power to avoid infection. "Susceptibility" is the converse of resistance. A different phenomenon is the power to avoid the ill-effects of the virus, and this is often quite independent of the plant's resistance to infection. For this quality the word "tolerance" appears appropriate, so that a tolerant variety yields well though diseased, while an "intolerant" variety suffers severely from the disease.

The most desirable variety economically is clearly an immune one. It now seems improbable that any variety at present grown in East Africa is immune from the severe strains of mosaic. Nor has any been found immune from brown streak, although it is too early to say

that none exists. The importation of exotic varieties is now being carried out through the quarantine station at Amani. The early results have not been encouraging, for the West African varieties, reported to be immune in their home, have proved to be fully susceptible here and highly intolerant of severe mosaic. Nevertheless, the importation policy will be continued, in the hope that an immune variety may yet be encountered. The prospects of success are not great, for most of the importations must come from countries where virus diseases do not attack the cassava; consequently these varieties will not have undergone a natural selection for resistance in their home.

It thus appears likely that we may be driven to confine selection work to the isolation of varieties of higher resistance than the average. It is already clear that there is considerable variation in resistance among local varieties. The recognition of highly resistant varieties, however, is a matter requiring prolonged experimental investigation. A start has been made by Mr. Humphrey at Kibarani Experimental Station, and over four years' trials his selected variety, Malindi, has shown high resistance to mosaic under local conditions. In trials of this kind the factor of tolerance must not be overlooked; for it is uncertain whether the most desirable variety in the end will prove to be one highly resistant to infection or one, perhaps of low resistance, that is highly tolerant of the effects of the disease. Thus the design of variety trials is a matter requiring careful consideration; for not only must the lay-out be such that all varieties are subject to an equal risk of infection, but the effects of the several disease factors that determine yield must be differentiated.

Sooner or later the services of the plant-breeder must be called in, in the hope that by the raising of seedlings, and particularly by controlled hybridization, intensified resistance may be combined with desirable economic qualities. Furthermore, there are important possibilities in a suggestion of the Director of the Imperial Mycological Institute. A great advance in the control of sugar cane mosaic followed from the crossing of the sugar cane plant with a wild species of *Saccharum* immune from the disease. He suggests that a similar procedure of crossing cassava with wild species of *Manihot* might provide immune or highly resistant varieties suited to our conditions. Over a hundred species of *Manihot* have been described, all indigenous to South America. To collect these species, to test their resistance to the several viruses, and to breed hybrids from them would be a long and arduous undertaking. It might prove to be a task well repaid.

The Organization of Agricultural Education in Uganda

By E. G. STAPLES, *M.A., Dip. Agric. (Cantab.), M.R.A.C., Superintendent of Agricultural Education, Uganda.*

In its widest aspect agricultural education may be said to be the concern of the whole of the staff of the Agricultural Department of a country such as Uganda. In fact, much of the work of every agricultural officer is necessarily educational.

With the general expansion of their work, however, and the steadily increasing demand for technical courses in agriculture, it was found necessary to create an Educational Division of the Department of Agriculture. This consists of a Superintendent of Agricultural Education and three agricultural officers, and deals with the organization of agricultural education generally, the holding of courses of instruction in agriculture for various sections of the community, the training of small-holders, and, in co-operation with the Education Department, giving, as far as is possible, an agricultural bias to the general school system of the country. The work falls naturally into two parts:—

I.—*Vocational Training in Agriculture.*—This includes the training of youths as small-holders or small farmers, and training of a senior African staff of assistants and a junior African staff of instructors for the Department. Under this heading, too, may be included the series of short courses that are held for chiefs.

II.—*The Organization of School Gardens and of the Teaching of Nature Study in the Schools,* especially the elementary schools of the country, with a view to imparting an agricultural bias to the education that is given to the bulk of the people. With this end in view short courses in these subjects are held at frequent intervals for schoolmasters, and no teacher is considered as qualified until he has attended such a course. These courses are followed up by school inspections to see that the lessons learnt are put into practice.

Most of the courses are held at the Department of Agriculture's two main experiment stations at Serere in the Eastern Province and at Bukalasa in the Buganda Province. Serere is typical of the "short grass", light soil areas of the Eastern and a large part of the Northern Provinces, and caters for pupils from those areas. Pupils from Buganda, Bunyoro, and other "elephant grass" areas attend courses at Bukalasa, where these conditions obtain.

At each centre the educational buildings include a lecture room, dormitories, and mess-room. There are also a number of model small-holdings at each centre, and these, in addition to their use by the small-holders, are used for demonstration purposes in connection with all the courses.

Vocational Training in Agriculture.

Small-holders' Courses.—These courses (which are held both at Serere and at Bukalasa) are of two years' duration, and are designed to train intelligent peasants and small landowners to run a small farm successfully. Candidates for these courses are required to have passed through an elementary school, to be able to read and write in their vernacular or in Swahili, and to know enough arithmetic to enable them to keep simple records. There are a number of small-holdings at each centre, on which the pupils work in small groups. The whole

of the work of the holdings is done by the pupils, under the close supervision of an agricultural officer. The mornings are occupied with practical work and instruction is given in management, the training of oxen, the use of ox-drawn sledges for haulage purposes, the making of farmyard manure and of compost, farm carpentry, rope-making, and the hundreds of small details of practical farming that are too numerous to mention here. The afternoons, except in the busy seasons, are given up to a lecture.

At Serere, there are three twelve-acre holdings, each of which is occupied by three married pupils. These holdings were started in 1933. Each holding has nine acres for economic crops and two acres for subsidiary food crops, the remainder of the area being occupied by the homestead and trees. Each holding has a team of six oxen, a plough, a small cultivator and an ox-sledge. There are, in addition, two cows and a small flock of poultry on each holding. The buildings comprise a dwelling-house (a simple two-roomed house, being a slight but definite improvement on the ordinary native hut of the district), a cattle-shed, calf-house, a store and implement shed, food store, and poultry-house.

Three further holdings were established in 1934. Two of these are of eight acres, and are each worked by a man and his wife. The third holding is of twenty acres, and is worked by ten bachelor pupils; these pupils also help with the work on the smaller holdings in the busy seasons. The lay-out and arrangement of these holdings is, in general, similar to that of the twelve-acre holdings. The main rotation on all the holdings is as follows:—

1st Year.—Cotton, early sown.

2nd Year.—Wimbi (small millet); cotton, late sown.

3rd Year. — Groundnuts; grass (mostly *Panicum maximum*).

4th, 5th and 6th Years.—Fallow under grass.

The rotation for the subsidiary food crops area is:—

1st Year.—Millet (*Sorghum*); beans.

2nd Year.—Simsim (*Sesame*); sweet potatoes.

3rd Year.—Sweet potatoes; cassava.

4th, 5th and 6th Years.—Fallow under grass.

Thus on each of the twelve-acre holdings saleable produce includes cotton from 3 acres, groundnuts from 1½ acres, in addition to an occasional calf, fowls, and eggs.

The holdings have produced a steady profit each year. As an example, it may be stated that the three original twelve-acre holdings, for the year ending the 31st March, 1935, showed an average profit of Sh. 165 per holding, in addition to producing enough food for the pupils and their wives.

At Bukalasa, there are two holdings: a twenty-one-acre "mixed" holding that is worked with a team of oxen, and a fourteen-acre holding worked by hand labour. At present only the smaller holding is used for teaching purposes. It is divided up as follows:—

Plantain garden	...	2½ acres.
Other food crops	...	2 ,,
Economic crops	...	6 ,,
Coffee (Robusta)	...	3 ,,
Buildings and trees	...	½ ,,
	Total ...	14 acres.

The main rotation on the "economic crops" area is:—

1st Year.—Cotton.

2nd Year.—Groundnuts; cotton (interplanted with beans).

3rd Year.—Simsim, followed by cotton.

4th, 5th, and 6th Years.—Fallow under elephant grass.

The subsidiary food crops rotation is:—

1st Year.—Beans; cassava.

2nd Year.—Cassava; green manure.

3rd Year.—Groundnuts; sweet potatoes.

4th Year.—Sweet potatoes; cowpeas.

5th, 6th, 7th and 8th Years.—Fallow under elephant grass.

The only live stock kept on this holding is a pen of selected native hens mated with a Rhode Island Red cockerel.

There is accommodation for eight pupils on this holding, and the first batch finished their two-years' course towards the end of 1935.

Pupils are only accepted for the small-holdings' courses from districts where an agricultural officer is stationed, to facilitate supervision when they start up on their own. The agricultural officer helps with the selection of land, the marking out of the pupils' holdings, and pays frequent visits to them to ensure that they get started on the right lines.

Before leaving the subject of the training of small-holders, it should be mentioned that two mission farm schools, one under the Church Missionary Society in Buganda and the other under the Verona Fathers' Mission in the Gulu District of the Northern Province, were started in 1934. These are both financed by grants from Government, and teach by means of small-holdings modelled on the lines of those at Bukalasa and Serere respectively. Both schools are doing useful work in training potential small farmers.

The Training of Agricultural Assistants.—A five-years' course in agriculture is open to students of Makerere College who wish to obtain a thorough all-round training in agriculture. This course has been in existence since 1925; it started as a three-years' course, and was lengthened to five years in 1933. Up to the present time all of the successful students have been taken into the Department of Agriculture as agricultural assistants.

Candidates must have passed the Junior Secondary Schools Leaving Examination before they are allowed to enter the course. Tuition is in English. The course is as follows:—

First Year (at Makerere College).—Continuation of general education.

Second Year (at Makerere College).—Pure science (physics, chemistry, botany, zoology), mathematics, English.

Third Year (pupils in residence at Makerere College, but instruction given by the staff of the Agricultural Department, except in diseases of stock, surveying, and book-keeping).—Agriculture: (1) crop production, (2) animal husbandry, (3) experimental agriculture; agricultural chemistry (theoretical and practical); agricultural botany; agricultural pests and diseases; diseases of stock (by an officer of the Veterinary Department); elementary surveying; book-keeping.

Fourth and Fifth Years.—These years correspond to the time that is required to be spent by an English agricultural student on a good farm. A complete year is spent at each of the Department of Agriculture's two main experiment stations at Serere and Bukalasa. The training during these years is entirely practical, and the students are given practice in all of the various departments of work at these centres, including the organization and management of labour, field

experiments, the management of small-holdings, etc. From time to time they accompany agricultural officers on tour, and gain experience in various lines of work; such, for instance, as village surveys. A course of lectures throughout these two years is designed to show the bearing on practice of their previous lectures and laboratory work.

The Training of Agricultural Instructors.—Short courses, usually of two or three months duration, are held each year at Bukalasa and Serere for the junior African staff of the Department of Agriculture and for instructors working under the various native administrations. These courses are kept as practical as possible, and, in addition to the principles of good husbandry, include instruction in the measurement of and laying out of plots, the identification of common crop pests, and in writing of simple reports.

Courses for Chiefs.—Short courses of from two to three months are held each year at Bukalasa and Serere for chiefs. These courses are planned to give the younger chiefs some knowledge of present-day ideas about agriculture, to arouse their interest in the subject, and to put them in touch with the work of the Agricultural Department. The syllabus includes practical instruction in soil conservation and the prevention of erosion, and the fundamentals of good cultivation, including, at Serere, correct methods of ploughing. These courses have been in existence since 1933, and it has been found that the chiefs attending them show very considerable interest in the work.

Nature Study and School Gardening.

In this work the Department of Agriculture work in co-operation with the Department of Education.

Nature study and school gardening now form an accepted part of the elementary school curriculum of the country. These subjects are therefore included in the syllabus of the several teachers' training schools. It was early realized that these schools had not the staffs or the facilities to teach these subjects efficiently. Arrangements were therefore made to hold short courses in these subjects for teachers at Bukalasa and Serere. The first of such courses was held at Bukalasa in 1930 and at Serere in 1931, and one or two courses have been held at each centre every year since then. The courses are usually of three months' duration, and are made as simple as possible, so that lessons learnt can be applied by the teachers when they go out to their schools. Separate courses are held for middle and secondary schoolmasters and for those from elementary schools. Every elementary schoolmaster is required to attend one of these courses before he is considered to have completed his training. These courses have undoubtedly had a marked effect on the teaching of these subjects in the schools. There is still much room for improvement, but as the standard of intelligence and general education of the schoolmasters improves, and as the African gradually comes to look upon education as a preparation for life in rural Africa, there is every reason to anticipate a steady advance in the standard of teaching of these admittedly essential subjects.

As far as other demands on the time of the staff will allow, the schoolmasters who have attended these courses are subsequently visited in their schools, and help and advice is given to them with regard to their school gardens and the teaching of nature study.

Shade for Coffee Plantations

As mentioned in the Editorial Notes of the previous issue, the Agricultural Research Conference held at Amani in February, 1936, decided that selected groups of the memoranda submitted to it should be edited for publication in the *East African Agricultural Journal.* The following memoranda are those dealing with the subject of shade in coffee plantations:—

(1) *Kenya.*—An article on "Coffee Shade in Kenya," by T. L. McClelland, has already appeared in this Journal (Vol. I, No. 2, pp. 107-118).

(2) *Tanganyika.*—The same issue contains (pp. 135-139) "Observations on Coffee under Artificial Shade at Selian Coffee Estate, Arusha," by D. Sturdy.

(3) *Uganda.*—Memorandum by Messrs. A. B. Killick, H. Hargreaves, and A. S. Thomas, of the Uganda Department of Agriculture:—

SHADE IN COFFEE.

It will be convenient to review the question of overhead shade in coffee—based on experience in Uganda—under the following heads: "Experimental" and "General Observations".

Experimental.

The following experiments have been or are being undertaken:—

Bugishu District (Arabica).

(1) Demonstration plots were established at 20 centres in Bugishu District in 1924, at altitudes ranging from 4,000 to 6,500 feet. At each centre there were three plots of 100 trees each, planted at 8 ft. x 8 ft., and pruned on the single stem system. One of these plots was planted with permanent shade trees, chiefly *Albizzia* and *Cordia* sp., at 40 ft. x 40 ft.; one plot was maintained unshaded, and the third was interspaced with plantains as a form of temporary shade at 16 ft. x 16 ft. Unfortunately, no systematic record of yields from individual plots was kept, and in 1933, having served their purpose, the plots were sold to native growers.

From observations made in the period 1931-33 the following general conclusions were drawn:—

(*a*) That plantains as temporary shade were detrimental to the coffee at all elevations, but particularly so at altitudes below 5,000 feet, where only a poor stand of trees remained in the plantain shaded plots.

(*b*) That at altitudes above 5,500 feet there was no noticeable difference between unshaded and permanent shade plots. None of the plots were planted at elevations sufficiently high to show the effects of shade on "hot and cold disease".

(*c*) That below 5,500 feet the coffee in permanently shaded plots was in a more healthy and robust condition than in unshaded plots, suffering less from *Hemileia,* leaf-fall, and "dieback".

(*d*) That at elevations below 5,000 feet in unshaded plots, biennial fluctuation in cropping was very noticeable, whilst in shaded plots the cropping was more even.

(2) Artificial shade experiment at Bugusege Plantation; planted 1932.

Treatments.

(*a*) Shaded throughout the year except for one month unshaded, beginning with the flowering season.

(*b*) As (*a*), but beginning to remove shade one month earlier.

(*c*) As (*b*), but beginning to remove shade one month earlier.

(*d*) Permanent shade of same intensity as (*a*), (*b*) and (*c*).

(*e*) Control; no shade.

Layout.

A 5 x 5 latin square, with 16 trees per plot and two guard rows surrounding each plot.

Cultural.

The trees are pruned on the modified multiple stem system, but in March, 1936, they will be stumped and trained on the single stem system. Those trees within the experiment from which yields are recorded are mulched with banana leaves twice a year; guard rows are unmulched and clean weeded.

Shade was erected at a height of 9 feet from the ground between October, 1933, and March, 1934, bamboo slats being used on a wooden framework.

Observations.

(*a*) *Vegetative Growth.*—The trees grew normally until the shade was erected, after which those under shade became somewhat etiolated in 1934 and more so in 1935, to such an extent that it has been necessary to raise the shade to 10 feet. The average distance between nodes is about 2.9 inches, as compared with 2.4 inches in unshaded plots. The leaves are a darker green colour under shade and thicker in texture. Secondary growth appears to be repressed under shade.

(*b*) *Flowering.*—In shaded plots flowering has been delayed compared with unshaded trees. In 1935 the lag was about three weeks.

(*c*) *Fruiting.*—Fruiting over the whole experiment has been delayed about a month as compared with corresponding trees in another unshaded experiment planted at the same time. The unshaded plots in the experiment were no earlier than the shaded plots, which points to another effect besides that of light intensity. From the first crop (1934-35 season) there were no significant differences between yields of the different treatments. The cherry does not ripen to such a good colour as in unshaded plots.

Bukalasa (Robusta).

Shade and Cover Crop Experiment.

Treatments.

(*a*) No shade; clean weeded.
(*b*) No shade; permanent cover crop (*Centrosema pubescens*).
(*c*) Banana shade; clean weeded.
(*d*) Banana shade; permanent cover crop.
(*e*) *Gliricidia sepium* shade; clean weeded.
(*f*) *Gliricidia sepium* shade; permanent cover crop.

Layout.

A 6 x 6 latin square, plots 70 ft. x 100 ft., coffee planted 10 ft. x 10 ft. square, shade trees planted 20 ft. x 20 ft. diagonal.

Cultural.

The coffee is grown on a three-stem system, all suckers being removed and new suckers allowed to grow only when an old stem is cut back. In September, 1933, half the *Gliricidia* shade was removed, and the remaining *Gliricidia* shade has been pruned periodically.

Results to date are:—

Shades x Covers.

(*a*) Clean weeding is better than the cover crop under no shade and banana shade.
(*b*) No shade and banana shade better than *Gliricidia* shade when the ground is clean weeded.
(*c*) No shade and *Gliricidia* shade better than banana shade with the cover crop.

That is, banana shaded plots are spoilt by a cover crop; unshaded plots are depressed by a cover crop; *Gliricidia* shaded plots are not significantly depressed by a cover crop, for the *Centrosema* makes less vigorous growth under shade.

Shades x Years.

(*a*) To date no difference between banana shade and *Gliricidia* shade.
(*b*) No shade good in first year, i.e. better than banana shade.

No shade better in the second year, i.e. better than banana shade and *Gliricidia* shade.

No shade crops in the third year, i.e. to the same level as banana shade and *Gliricidia* shade.

Bukalasa: Types of Shade Tree.

Demonstration and observation plots are being established at Bukala, with Robusta growing under the following shade trees:—

(*a*) Natural (*Acacia* sp.).
(*b*) Mutuba (*Ficus* sp.).
(*c*) *Albizzia stipulata.*
(*d*) *Erythrina* sp.
(*e*) *Leucaena glauca.*
(*f*) No shade.

GENERAL OBSERVATIONS.

(*a*) Based on numerous observations, made over a considerable number of years, the Entomologist is of the opinion that from a pest point of view the provision of overhead shade is undesirable, both *Stephanoderes* and a Capsid bug (*Lycidocoris*) being definitely favoured by shade conditions. The position of *Antestia* is uncertain, but again this pest seems to prefer shaded conditions.

(*b*) Robusta coffee is in its natural habitat a shade-loving species. In some cases, when

growing wild under forest conditions, its growth is so dense as to form a complete undergrowth. On the Sese Islands and in Kyagwe (Mengo District) many instances can be seen of very old trees in very healthy condition growing under shade, whereas large numbers of Robusta trees planted by natives in recent years without shade have died after bearing one or two crops. This dying out at four or five years old is due to failue to control weed growth, more particularly grass weeds, accentuated by the tendency of Robusta when unshaded to overbear when young. The provision of proper shade tends to prevent this heavy overbearing in the early stages and to a marked degree keeps down the growth of weeds. There is no doubt that under Buganda conditions Robusta can be maintained in good condition for many years by proper attention to cultivation, i.e. by control of weed growth, and more especially when the ground is mulched—and the same applies to native-grown Arabica in Bugishu District—but observation tends to show that if the trees and the land in which they are growing are neglected, Robusta will live longer under shade than is grown unshaded.

(*c*) In Bugishu, at altitudes between 5,300 and 6,300 feet, shade for coffee appears to be unnecessary, but below this range it appears beneficial by reducing biennial fluctuation, and in the colder climate above 6,300 feet it may be beneficial; but this latter point has not been proved.

(*d*) An experiment now being undertaken on the Kampala Plantation has the following treatments:—

No Shade:

(*a*) Permanent cover crop.
(*b*) Weed cover; slashed periodically.
(*c*) Mulched with elephant grass.
(*d*) Clean weeded.

Overhead Shade:

Periodical green manure.

Throughout the experiment, once a fortnight estimations have been made of the water content and of the nitrate content of the soil. With regard to moisture content, the water content of the mulched plot is always much higher than that of any other treatment. At first the shaded plot and the clean-weeded plot showed a higher content of nitrates than did the other plots; while the shaded plot has continued to be pre-eminent in this respect, the clean-weeded plot now differs but little from the other plots; in fact, for some months the mulched plot has been slightly richer in nitrates. In addition, records of soil temperatures and of evaporation as measured by Piche tube have been kept. With regard to soil temperature it has been found that at a depth of two inches the temperatures recorded under shade show much less variation than those in the open, and that the maximum temperatures under shade may be as much as 10 degrees lower than those recorded in the open. Trials with Piche tubes at Kampala have shown that there are only relatively small differences between the records obtained from the tubes suspended at heights of 2 ft., 4 ft. and 6 ft. above the soil in any one place, and that the rate of evaporation among coffee under shade is always slightly below that among unshaded coffee.

(*e*) It is suggested that experiments undertaken to determine the effect of shade or of a particular ground treatment should be on a scale sufficient to allow costings to be kept. For example, when consideration is being given to the comparative merits of shade and grass mulching, while it may be found that grass mulching gives the heaviest yields, the cost of mulching may be out of all proportion to the increased yields obtained, and it may be economic to sacrifice maximum yields and to be satisfied with lower yields each year, with low weeding costs, which result might be obtained by the provision of suitable overhead shade.

(*f*) When new land is being cleared for coffee, if shade is desired a number of native trees appear to be suitable. For example, the figs, Mwafu (*Canarium Schweinfurthii*) and Musizi (*Maesopsis Eminii*), although not leguminous, are regarded as beneficial, whereas the Mperwere (*Piptadenia Buchananii*), although it is leguminous, is reputed to be unsuitable. Of introduced trees, our present experience indicates that *Albizzia stipulata*, although not perfect, would be the most generally useful, and if shade was being tried in native plots this tree or the native Mutuba (*Ficus* sp.) might be used.

(*g*) The Assistant Botanist is of the opinion that for the establishment of Robusta coffee by natives there are certain advantages to be gained from the proper use of bananas as shade. This practice has been followed by the natives of Uganda who have been growing Robusta coffee perhaps for hundreds of years, and there are to be seen many instances

of coffee and bananas, both widely spaced, and both in excellent health. It is true that the coffee under these conditions may form excessively long internodes, but it is considered that this disadvantage is more than compensated by the reduced competition from weeds that such coffee enjoys, when compared with coffee planted in the open, for it is difficult in Buganda to induce natives to pay proper attention to a crop from which they are obtaining no immediate return.

(4) *Nyasaland.*—Memorandum by the Department of Agriculture, Nyasaland:

In the coffee areas of Nyasaland the climatic year can be divided into six wet months and six dry months. During the dry period the lower limit of average rainfall which is regarded as essential is five inches. As a rule, much of the dry-season rainfall is ineffective, and the long dry spell must be met by the provision of shelter belts, shade trees and surface mulches.

Various trees and plants are under trial in Cholo and Zomba districts. They include the indigenous *Brachystegia* and *Uapaca*, examples of which have been left in clearings, *Albizzia, Acacia, Schizolobium* and *Grevillea* for high shade. For medium shade and hedges, *Sesbania, Gliricidia maculata, Derris robusta, Millettia oblata, Cytisus alba,* and *Cajanus cajan* are in use.

(5) *Northern Rhodesia.* — Memorandum by the Department of Agriculture, Northern Rhodesia: —

Coffee is grown at Abercorn at altitudes between 4,000 and 6,000 feet. The majority of the existing plantations were established after 1928. The average rainfall is about 45 inches, distributed between September and May, and irrigation is desirable if not absolutely essential.

Shelter from prevailing winds is unquestionably necessary, but the need for shade is at present doubtful. *Tephrosia vogelli* has been found satisfactory as a temporary shade and shelter for young coffee grown under irrigation.

Observations on estates where certain indigenous trees were left to provide shade have shown that moderate stands of the following are at least harmless: —

Parinarium mobola.
Afrormosia angolensis.
Pterocarpus angolensis.
Albizzia antunesiana.
Albizzia gummifera.

On the other hand, most of the *Brachystegias* and *Isoberlinias* (particularly *I. paniculata*) are harmful, and an unidentified species of *Anisophyllea*, in particular, inhibits the growth of coffee near it.

The Influence of Forests on Climate and Water Supply in Kenya

By J. W. NICHOLSON, *formerly Forest Adviser to the Governments of Kenya and Uganda.*

INTRODUCTION.

The influence of forests on the climate and water supply of Kenya is a subject of great interest and importance to the majority of the farming population of the Colony. During recent years various farmers' associations have passed resolutions urging the local Government to adopt a bold policy of forest conservation and afforestation. Owing to the interest which is taken in the subject it is desirable that the public should be enlightened regarding the present state of our knowledge of the climatic effect of forests in the world in general and in Kenya in particular. It is with this object that this pamphlet has been written.

In certain respects this pamphlet may be considered as premature. For one thing very little is known of meteorological conditions in East Africa, and our knowledge of such conditions is likely to be amplified in the course of the next few years through the observations of the meteorological service which has been initiated this year. Again, very little forest research work has as yet been carried out in East Africa. If a Forest Research Institute is established in East Africa in the near future—a highly advisable project, then much light may be thrown by its investigations on problems which up to date have not been elucidated. Such investigations, however, whether meteorological or forest, will take time, and in the meantime it is desirable that the forest policy of the Colony should be based on existing data and observations.

CHAPTER I.

Miscellaneous Influence of Forests on Climate.

From the point of view of the residents of Kenya the most important influences of forests are those which concern rainfall and water supply. These effects are controversial, and before considering them it is proposed in this chapter to refer to some of the other climatic influences of forests which are less the subject of controversy.

Firstly, forests exercise a moderating influence upon the temperature of the air by their action in using up heat and converting it in to latent heat through transpiration. Observations carried out over several European countries have shown that in the forest the maximum temperature is always lower, and the minimum temperature higher, than outside. The yearly mean temperature is less inside than outside a forest. In a level country this difference is about 0.9° F., but it increases with altitude. The monthly mean temperature is less in the forest than in the open for each month of the year, but the difference is greatest during the summer months, when it may reach 3.6° F., while in winter it does not often exceed 0.1° F. The daily mean temperature of the air within the forests is therefore not only lower but also less subject to fluctuation than in the open.

It is in tropical and sub-tropical regions that the influence of the forest upon the temperature of the air is probably greatest. In the Amazon River basin, despite great distance from the ocean and

proximity to the equator, the average temperature of the warmest month is not greater than at the sea. The evidence of other tropical countries, such as India, confirms the moderating influence of forests on climate.

The influence of forests upon temperature is not confined to the forests themselves but extends vertically upwards. Renand, of the Central Military Balloonist Institute of France, states that the effect of the forests upon the temperature of the upper strata of air has been repeatedly felt during the ascension at an elevation of nearly 5,000 feet over the Forest of Orleans, which has an area of 75,000 acres. This influence is scarcely felt over field crops, and it can only be accounted for by the greater amount of water given off by forests (*see* Chapter II).

Secondly, forests influence the temperature of the soil in almost the same way as they do that of the air, but the differences in temperature outside and inside the forest are greatest in the case of soil. This is explained by the fact that the temperatures of bodies of air near one another tend to become equalized by the passage of air currents. Moreover, the surface of the soil is heated directly by the sun, while the air receives its heat chiefly from the surface of the soil, so that the difference between the temperature of the soil in the forest, where the ground is partially protected from heat, and that outside of the forest is especially pronounced. This difference is manifest down to considerable depths. The latest European investigations show that the forest soil is warmer in winter by 1.8° F. and cooler in summer by from 5.4° to 9° F. than soil without a forest cover, and that this holds true for a depth of as much as four feet. The difference in the temperature of the soil inside and outside a forest depends to some extent on the species of tree comprising the forest. A remarkable instance of such temperature differences was noted near Zurich in August, 1894, when the soil on an open southerly slope attained a temperature of 91.4° F. Under a young beech forest close by, on the same slope, the temperature was only 63.3° F.

Thirdly, the relative humidity of the air in forests is higher than in the open, except in regions of heavy snow during the time of snow melting. The reasons for this higher relative humidity are that the transpiration of water by the leaves appreciably increases the moisture content of the air within or near the forest, and that as the temperature of the air in the forest is lower it is nearer its saturation point. The difference in the relative humidity of the air varies from 4 to 12 per cent, being greater in summer than in winter. These figures are for European conditions. In the tropics the difference is likely to be much greater, particularly where areas outside the forest are swept by desiccating winds. One important result of such higher relative humidity and protection from desiccating influences is that the evaporation of moisture from both water and soil surfaces is less within than outside forests. In the case of evaporation from free water surfaces, numerous European experiments have proved that it is two and a half times greater outside the forest than inside. In the tropics that difference is likely to be still greater.

Fourthly, forests are the most effective agents for protecting the soil from erosion, because the resistance of the soil to erosive action is increased by the roots of the trees which hold the soil firmly in place, and, at the same time, the erosive force of the run-off is itself reduced, because the rate of its flow is checked and its distribution over the surface equalized.

All over the world there are examples of the evil erosive actions of streams following upon the removal of forest cover, and in some parts forest destruction has involved complete desolation. As the subject of erosion is intimately connected with the run-off, it will be dealt with more fully in a later chapter.

The above effects of forests may not appear to be of much importance so far as the economy of Kenya Colony is concerned, but apart from the effect on soil temperatures the other effects intimately concern the problems of rainfall, run-off and wind desiccation, as will appear from consideration of the chapters to come.

CHAPTER II.

Forests and Rainfall: The General Controversy.

The influence of forests on rainfall and other forms of atmospheric precipitation is a subject which has been much debated. For centuries it has been a popular belief that forests induce or attract rain. Such belief has had two main foundations. Firstly, wooded areas on the whole obviously receive more rainfall than areas devoid of growth. This fact does not, however prove that the forests create rain, as more often than not it is the rain that creates the forests. Secondly, the relative humidity of the air is greater inside forests than outside forests, and the beneficial effects of such humidity on crop production within wooded tracts has led to popular beliefs that such areas obtain more rain. It is here proposed to summarize the present state of our knowledge on the subject, and fortunately for our purpose two papers representing respectively the rival views and embodying all modern data have recently been published. The first of these is a work by Raphael Zon, of the United States Department of Agriculture, entitled *Forests and Water in the Light of Scientific Investigation*, and published in 1927. The second consists of a paper on *The Influence of Forests on Rainfall and Run-off*, which was read by Dr. C. E. P. Brooks before the Royal Meteorological Society in November, 1927.

Zon is a protagonist of the view that forests induce rain, and he puts forward a large number of data and observations to support his views. Unfortunately, he ignores contradictory data, and his sweeping generalizations do not bear scientific analysis. While we must therefore ignore his conclusions, we can, however, utilize many of the data he has collected together, as in fact we have already done so in Chapter I. Dr. Brooks takes the opposition view, and while his treatment of the subject is more scientific than Zon's he also, but to a lesser extent, attempts to generalize. This is a fatal mistake, and it is due to similar mistakes in the past that no agreement has been reached on the whole problem. Because in certain localities and in certain circumstances forests do not induce rain, it is wrong to argue that forests generally cannot induce rain. Conversely, if in general circumstances it may be proved that forests do not induce rain, it is wrong to assume that in particular circumstances they never can induce rain. How and where Dr. Brooks fails we will attempt to show in the analysis of his presentation of the subject which is given below.

Dr. Brooks starts off by pointing out that, before water vapour can be condensed as rain, it has to be got into the air, and therefore the first problem to be investigated is whether vegetation in general and forests in particular can influence the amount of water vapour in the air. He states that "this is one of the most difficult aspects of the whole ques-

tion and one which has been most obscured by the facile but fallacious reasoning of plausible advocates". It is just such reasoning which Dr. Brooks himself adopts. He states that "according to the calculations of G. Wust, the total rainfall over the continents amounts to 112.1 thousand cubic kilometres. The total run-off into the oceans is 37.1 of these units, giving an evaporation of 75.0 units. Of this water vapour evaporated from the land, part is again condensed as rain on the land, and another part, x, is carried out to sea. Hence the amount of water vapour carried from sea to the land and deposited there is equal to $37.1 + x$ units. If we suppose that off-shore winds contain on the average half as much water vapour as on-shore winds, we find that x is also equal to 37.1 units. That is, about two-thirds of the rainfall over the land is due to water vapour from the sea, and the remaining third to water vapour evaporated from the land, so that changes in the covering of vegetation may effect the total rainfall appreciably but not enormously."

If the above calculations were correct for all localities there would be some grounds for asserting that vegetation is of less account than the sea in affecting rainfall, but the problem would still be left open whether wooded areas do or do not attract more rainfall than unwooded tracts. However, Wust's are not the only calculations. Zon quotes others. Of the 44,015,400 square miles of land surface of the earth, 79 per cent drains directly towards the ocean and 21 per cent forms an inclosed inland area without ocean drainage. The 79 per cent may be called the peripheral area of the earth's surface, and the importance of the evaporation from it is, on the whole, very great. Prof. Ed. Bruckner computes the "continental vapour" evaporated from this peripheral area to be about 21,000 cubic miles, and he considers that it plays even a more important part in supplying moisture to the air than does the vapour directly evaporated from the ocean. He further draws up a balance-sheet to show the circulation of water on the earth's surface, and an analysis of the figures given discloses the fact that one-fifth of the entire vapour on the earth's surface comes from evaporation on land; and that only 7 per cent of all the precipitation evaporated from the oceans enters into the precipitation over land; and that 78 per cent of all the precipitation that falls over the peripheral land area is furnished by this area itself. In the interior enclosed basins the precipitation and evaporation are, as a rule, equal.

We thus note that Brooks and Zon quote respectively those authorities whom it is most convenient for them to quote. Which authority is correct? This is a matter for unbiased meteorological experts to decide, but we can advance facts to prove that, however correct Wust's calculations may be in general, they are less applicable to particular countries such as Kenya and Uganda than are those of Bruckner. In Uganda the only outlet of any importance is the River Nile. The outflow of the Nile at Nimule is approximately equivalent to 10 per cent of the total rainfall over Uganda—a very different figure from the 33 per cent quoted by Wust. In Kenya, the run-off into the sea has not been measured, but it is likely to be still less than 10 per cent. This means that Kenya and Uganda as a whole almost fall into the category of enclosed basins, and in actual fact parts of both countries do form enclosed basins. Further, the physico-geographic features of Kenya, Uganda and neighbouring countries are such as to render it extremely improbable that ocean vapour

can adequately penetrate into all parts of Kenya and Uganda.

Our first conclusion is therefore that there are certain regions of the world, which include at least parts of Kenya and Uganda, where the total rainfall is likely to be affected by changes in the covering of vegetation, not only appreciably but possibly enormously.

Dr. Brooks next sets out to prove that forests are unlikely to produce as much water vapour as other forms of vegetation. The loss of water from forests falls under three heads: (*a*) the rainfall intercepted by the crowns of the trees and re-evaporated without reaching the ground; (*b*) the water evaporated from the soil of the forest; (*c*) the water transpired by the trees. Dr. Brooks quotes various researches into the subject of the loss of water from forests, and sums up the data in the following table expressing the addition of water vapour to the atmosphere in percentage of rainfall:—

	Forests.	*Crops.*	*Bare Soil.*
Interception of rainfall	15	—	—
Evaporation	7	17	30
Transpiration	25	37	—
Total ...	47	54	30

He admits that these figures are very rough, but claims that they are borne out by the percentage rates of run-off to rainfall for European rivers such as the Rhine, Danube, Seine, etc. He considers then that "the replacement of forest by cultivated crop land is likely to increase the general rainfall of the district slightly rather than to diminish it. On the other hand, the decreased loss of moisture in the air over forests means that the local run-off is greater than from crop land, and this likely to be the more noticeable effect. The replacement of forests by bare ground should decrease the general rainfall and increase the run-off, though the latter would of course become much more variable. It may be remarked that forests draw their supplies from greater depths than do ordinary field crops or grains, and in times of drought are likely to continue supplying moisture to the air after unirrigated field crops have exhausted the surface water. Where the conditions are favourable for the re-precipitation of this moisture as instability showers, large areas of forest may mitigate the severity of the droughts. I am, however, unable to adduce any actual measurements of rainfall in support of this conclusion!"

As usual, Zon has other figures up his sleeve. He states that the experiments of Otozky have conclusively shown that the forest, on account of its excessive transpiration consumes more moisture, all other conditions being equal, than a similar area bare of vegetation or covered with some herbaceous growth: "The amount of water consumed by the forest is nearly equal to the total annual precipitation; in cold and humid regions less, and in warm and dry regions somewhat greater. This enormous amount of moisture, which is later given off into the air by the forest, may be compared to clouds of exhaust steam thrown into the atmosphere, and must necessarily play an important part in the economy of nature." Further on in his work, Zon gives some actual figures on the lines of those given by Dr. Brooks. (It will be noted that according to these figures the loss of water by transpiration is much less than it is according to Otozky. This is because Zon is now dealing with another subject, the influence of forests on run-off, and Otozky's results are not convenient to him.) These figures may be totalled as follows to express the addition of water

to the atmosphere in percentages of rainfall:—

	Per cent.
With leaf litter—	*Per cent.*
Beech forest ...	62
Pine forest ...	49
Spruce forest ...	76
Without leaf litter—	*Per cent.*
Beech forest ...	64
Pine forest ...	54
Spruce forest ...	82
Potato field ...	43
Grain field ...	80
Field crops in general ...	62

Zon's figures are strikingly different from those of Dr. Brooks. The reason is that the amount of water given off by a forest depends on several factors, such as the age of a forest, the character of the rainfall, i.e. heavy or light, but above all, on the species of trees comprising the forest. Dr. Brooks's figures of transpiration are based on Hohnel's average estimate for beech of 25 per cent of the rainfall. He might equally well have employed Hohnel's percentages of 43.5 for elm and 40.0 for birch. However, it is no use arguing over figures, for the latter all concern European conditions, and are inapplicable in the tropics, and especially in East Africa. The main point in East Africa is that we have to deal with seasonal rains and periods of drought. Dr. Brooks makes a light passing reference to such climatic conditions. We cannot dismiss them because they are fundamental to our investigations. If there is some doubt whether under European conditions forests give off more or less moisture than other forms of vegetation, there is not the slightest doubt but that in East Africa trees and deep-rooted shrubs give off far more moisture than herbaceous vegetation, as during seasonal periods of drought the latter is not transpiring, while the former (with the few exceptions of species which lose their leaves for lengthy periods) are doing so.

As regards bare soil, attention must be drawn to the fact that under tropical conditions of intense heat the evaporation from bare soil may be so intense as to exceed transpiration and evaporation from a forested area, particularly if the latter is leafless during the dry season. Practical experience, however, would indicate that such intense evaporation only proceeds for a short period, while there is still abundant moisture in the soil, and pending further scientific observation there are no grounds for assuming that bare soil can give off greater total quantities of moisture than soil under vegetation.

Our second conclusion is therefore that in East Africa trees and deep-rooted shrubs contribute more moisture to the air than herbaceous vegetation or bare soil, and they are therefore more likely to influence rainfall than the latter type of vegetation.

(*To be continued.*)

Some Observations on Birds Raiding Rice Fields in Kilosa District, Tanganyika Territory

By N. R. FUGGLES-COUCHMAN, *B.Sc., M.B.O.U., Agricultural Officer, Tanganyika Territory.*

Anyone who has been in a rice-growing area when the rice is beginning to head and set grain will not have failed to come rapidly to the conclusion that birds are an important economic pest of the rice crop. This will have been impressed upon them by the number of natives who sit in their small rice fields from dawn to dusk, halloaing, cracking whips, or throwing mud pellets at the flocks of birds which are constantly in flight over the fields. For some two months of the year it is a full time occupation for any rice-growing native to guard his crop against these marauding flocks, so that in a rice area the air is filled with a constant shouting and screaming as a flock approaches a series of *shambas*, to be scared to another area, there to give rise to further frenzied screams or whip-cracking. It will be realized that the loss to the native is thus twofold: direct in regard to the grain actually eaten, and indirect in the hours of his time which must be spent in attempting to drive off the birds from the fields, hours which, if they could be saved, might be used in the planting and taking care of other crops. It is often stated that natives are on the average lazy, the areas of crops which they plant being considered much less than their strength would warrant. This may be true in many cases, but there must be taken into account such inroads into their time and strength as the scaring of birds, and the protection of their cultivations from game, which entails constant sleepless nights in their small huts among their crops. Under ideal conditions the native should be able to produce considerably more, in many cases even under present conditions, but he is working against large odds in most areas.

LOCALITIES OBSERVED.

The observations herein recorded were made with a twofold object. Besides investigating the species which were responsible for the raiding, I had hoped to obtain from those observations some estimate of the loss of grain which takes place from bird-marauding in rice fields. I found the latter not entirely possible, but certain figures obtained give an indication of that loss, while other interesting points have appeared. Rice fields in three different types of country were visited from time to time over two years of cropping, but owing to the comparatively short time during which useful observations could be made, and to other calls on my time, those visits were not as numerous as I would have desired. The three areas, which may be designated for further reference A, B and C, are described below. Kilosa District is situated some 175 miles from the coast and the three areas lie approximately at an elevation of 1,600 feet above sea-level on or near the Central Railway, which passes roughly through the centre of the district from east to west. Directly to the north lie the foothills of the Ukaguru Mountains, which rise to some 6,000 feet above sea-level.

Area A.—A small patch of rice about twelve acres in extent, planted in a low-lying cup which collects the rain and becomes a swamp for some five months of the year. This area at the time of the observations was surrounded by maize

and millet fields, and areas which were not cultivated were covered with tall grasses, such as *Panicum maximum*, *Hyparrhenia rufa* and *Rottbellia exaltata*. There is no river nearby, the River Mkondoa being about one mile distant. A few trees, mainly mangoes and *Kigelia* sp., are scattered about on the higher land.

Area B.—A larger rice area in the Kidete Valley of the River Mkondoa. The rice fields are scattered and often separated by large areas of *Penisetum purpureum*. The fields are inundated by the Rivers Mkondoa and Lumuma during the long rains in March. The two rivers bound the area, and have along their banks considerable quantities of tall waterside grasses and bulrushes. The valley is about three miles wide, and is bounded by dry rocky hills, which are covered with dense baobab-thorn-sansevieria thicket. There are very few trees in the rice area itself.

Area C.—A large continuous area of rice, about 100 to 150 acres in extent, on the edge of the great Mkata Plain. The fields are inundated by the River Miombo in February and March. The surrounding country is *mbuga*—short grass with very scattered trees, mainly thorn and *Borassus* palms.

Raiding Species and Factors Influencing their Presence.

A collection was made of the chief raiding species in each area, and rough estimates were made of the numbers alighting in a definite area of rice. A number of the most numerous species was also collected for crop and stomach counts of rice grains, from which to obtain some estimate of the loss of grain due to their feeding. The three areas are dealt with separately below.

Area A.—The rice fields were visited near the end of May, when the rice was in full head and the grain mainly in the milk stage, at which time it appears to be more attractive to birds than when it has nearly ripened. Practically the whole swamp was planted with rice in small fields belonging to a number of natives, many of whom were present, scaring off birds. The following species were seen or collected in the rice fields:—

Saxicola torquata robusta (African Stonechat): One male.

Vidua macroura (Pin-tailed Whydah): Few males and several females.

Euplectes hordacea changamwensis (E. Coast Fire-crowned Bishop): Innumerable males and females.

Xanthophilus aureoflavus sub-sp. (Golden Weaver): One female and three others.

Lagonosticta senegalla rendalli (Fire Finch): Several small flocks.

Estrilda astrild cavendishi (Common Waxbill): Several small flocks.

Cisticola galactotes suahelica (Swamp Cisticola): A few scattered pairs.

Crops and stomachs were examined, and rice was found in those of *Euplectes*, *Vidua*, *Xanthophilus* and doubtfully in *Estrilda*. Thus it will be seen that of the grain-eating species the *Euplectes* were by far the most numerous, while other large weavers were practically absent, three of the four *Xanthophilus* being in flight and passing over the rice while I was there. The *Euplectes* were in small flocks of ten to thirty, so far as one could count them in the speed of their flight and settling. No flock ever went far from the rice fields when scared away, either passing on to a patch of unguarded rice or flying into the surrounding millet fields and grass. From what could be gathered these flocks were purely local, having nested and formed up in the vicinity of the rice fields, the uncultivated areas of which were ideal for nest-

ing. In view of their being so much more numerous than other grain-eating species in the rice, the *Euplectes* could be termed the dominant raiding species in Area A, the next most numerous species being the *Vidua*. Female whydahs of other species may have been among the latter flocks, but males of the named species only were seen. These again, as far as one could gather, were local birds, the flocks going no great distance from the rice fields, while the local habitat and birds were suitable for their breeding. (This whydah is parasitic in its nesting habits.) As the area was a comparatively small one and very well guarded, there was little chance to make counts of birds alighting in an area of rice, since no sooner were they seen approaching than loud cries and whip-cracking commenced, the flock veering off to some other field or to the surrounding millet fields. One small patch of about a quarter of an acre was not being guarded, and 30 *Euplectes* were counted coming into the rice in two minutes, arriving in small flocks. I scared these away, and in the next ten minutes only nine settled, together with three *Vidua* and two *Cisticola*. In the next 15 minutes 26 *Euplectes* alighted in the rice together with four *Vidua* and two *Estrilda*. It appeared that after birds had been scared away they were slow in returning, but once some birds had settled their numbers were quickly increased by other birds, which presumably saw them and alighted amongst them. This was very evident in Area C. The number of birds settling and marauding will be seen, however, to be very different from those recorded for the latter, an area surrounded by much less cultivation, and more suited to the breeding of the various depredators.

Area B.—The fields of this area were not as continuous as those in either of the other areas under notice, and were frequently bordered by excellent nesting sites for species of weavers, especially along the banks of the rivers and in one or two swampy areas. Visits were unfortunately only of short duration, but what was seen was sufficient to show the dominant species of the area. The following species were collected or seen in the fields:—

- *Ploceus jacksoni* (Golden-back Weaver): Numerous males.
- *Xanthophilus aureoflavus* sub-sp. (Golden Weaver): Several males.
- *Euplectes hordacea changamwensis* (E. Coast Fire-crowned Bishop): A few individuals.
- *Euplectes capensis* (Yellow and Black Bishop): A few individuals.
- *Amblyospiza albifrons albifrons* (Grosbeak Weaver): One or two only.

Whydahs were not recorded on either of the visits, while one or two *Estrilda astrild* and *Cisticola* sp. were also seen. Of the above, by far the most common raiders of the rice were the *Ploceus jacksoni*, together with *Xanthophilus aureoflavus*, which were rather less numerous than the former. The *Suplectes* sp. were much less common than either of the foregoing, and at the time of the visits seemed to be only a minor pest. The *Ploceus* sp. and *Xanthophilus* were nesting in large numbers along the rivers and borders of the swamps, together with a few *Amblyospiza*, and here and there *Euplectes hordacea*. Those birds watched returned to their nesting colonies, or flew down from them into the rice, so that there appeared to be no actual raiding by any migratory flocks.

Area C.—The rice fields of this area covered a much larger acreage than in either of the two previous areas of cultivation, and were almost continuous; here and there being patches of the previous

season's fields which had not been cleaned and which were covered with comparatively short grass, an *Hibiscus* or *Abutilon* sp. and shrubby growth. This type of vegetation was also common round the edge of the rice area, outside which was the short grass country of the Mkata Plain, as described above. Visits were paid when the rice was in full head, the greater part of the main crop being at the milk stage, the earlier varieties ripening. The following species of birds were collected or seen in the fields:—

Quelea erythrops (Red-headed Quelea): Innumerable males and females.

Urobrachya axillaris axillaris (Red-shouldered Whydah): Seen singly, males and females.

Euplectes hordacea changamwensis (E. Coast Fire-crowned Bishop): Very few males and females.

Cisticola sp. (Grass Warbler): One or two pairs.

Streptopelia sp. (Dove): One or two seen in flight over the fields.

No other species were noticed in the rice fields and practically all the raiding was by flocks of *Quelea erythrops*, that were constantly dropping into unguarded patches of rice. Of the *Euplectes hordacea* none was in the rice itself, but from their proximity to the rice, in the uncultivated edges of the fields, I have no doubt they were raiding the grain. The interesting point is that they were in such small numbers. The *Urobrachya axillaris* were only seen as solitary males, both in the rice and uncultivated areas, but they were also in very small numbers. Thus the dominant species was the *Quelea erythrops*.

I have not been fortunate enough to encounter the *Quelea* at their nesting site but I was emphatically assured by the natives that the flocks seen in the rice fields had bred out in the Mkata Plain, and migrated thence to the fields. Amongst the birds shot only one male had enlarged testes, and there were many immature birds in the flocks, which supports that statement. It may be noted in passing that this species was not encountered in either of the other areas. Area A lies some twelve miles from Area C as a bird flies, and Area B is about twenty miles further on. Thus what migration possibly has been observed is suspected to be only of a very local nature, but further observations would be necessary to establish this point satisfactorily.

It was difficult to find an unguarded rice field in Area C, but one such area, about one acre, was watched for a quarter of an hour until the owner arrived. If a few *Quelea* were allowed to settle in the rice and started feeding, they appeared to act as a magnet to other passing flocks, which stopped as one bird and alighted in the same patch of rice. In ten minutes ten flocks of *Quelea* settled in the field under observation. The numbers of each flock were roughly estimated, the size of the ten flocks varying from four to forty birds, with a total of 270 birds in ten minutes. During that period one flock of about thirty passed over without alighting. In a further 2½ minutes approximately another 190 birds dropped into the rice, by which time the owner arrived and frantically drove them off. It is impossible to say how long they would have stayed had he not returned, but from their apparent rapid feeding they would probably have filled their crops from the field. During the period of observation no birds left the field and their numbers were constantly reinforced by new flocks.

From the foregoing it will be seen that in each of the three areas studied there

were one or two species dominant amongst the raiders. In Area A it was the *Euplectes hordacea*; in Area B, *Ploceus jacksoni* and *Xanthophilus aureoflavus*; in Area C, *Quelea erythrops*. In each of these cases (with the possible partial exception of Area C) the dominant species was to be found breeding in the vicinity, and as the vegetation and local habitat differed from area to area, so the species breeding in largest numbers in the area changed. There seemed little or no tendency for birds of grain-eating species to invade the fields from a distance. Thus Area A was barely one mile from the River Mkandoa where a large number of *Ploceus* of various species were nesting. Three *Ploceus* only were seen in that area on any visit. Area B was not so suitable a habitat for *Euplectes hordacea* as Area A, since most of the tall grasses were over water in swampy ground or along the edges of the rivers, which situations do not seem so frequently used as long grasses on dry land. Beyond the rivers was only short grass country, or cultivations, as unsuitable as the very short grass country surrounding Area C. What few birds were seen of that species were local birds which were nesting in the small patches of suitable grasses which existed. In the case of Area C there appeared to a local invasion of the *Quelea erythrops*, but from what distance I cannot say, since I was not able to discover their nesting place. However, of the grain-eating species present, they were the best suited by the surrounding country. One is led to the conclusion that generally speaking the amount of raiding which takes place depends almost entirely upon the suitability of the local uncultivated areas as a nesting habitat for grain-eating species, the particular species being determined by the general vegetative conditions of the country in the vicinity of the rice fields.

This observation agrees in general with Moreau's statement (1) in reference to a swampy river valley utilized for rice-growing in a dry thorn-bush area of the Usambaras. He observes that while the surrounding thorn-bush was inhabited by several species of seed-eating birds, the only raiding of the rice was done by those species characteristically associated with swamp vegetation or long grass. It is also suggested by him (in lit.) that another important factor influencing the loss of grain will be the comparative sizes of the rice area and the uncultivated area, the percentage losses being heavier in a small area of rice than in a larger area, each being surrounded by the same area of suitable nesting ground.

Loss of Grain Due to Birds in Area C.

The crops and stomachs were examined of sixteen *Quelea erythrops* which were shot in Area C, from which the following counts of rice grains were obtained:—

Bird	Crop	Stomach	Total
i	20	Fragments	20
ii	2	5	7
iii	5	2	7
iv	6	4	10
v	15	6	21
vi	1 and small other grains	5	6
vii	28	4	32
viii	1	3	4
ix	0	3 and fragments	3
x	0	0	0
xi	2	5	7
xii	4	3	7
xiii	Grass seeds	1 and grass seeds	1
xiv	1	1 and fragments	1
xv	33	8	41
xvi	5 and insect	3	8

It had been hoped that from such counts a satisfactory estimate might be made of the losses in grain due to birds, but it is now realized that it is of necessity merely hypothetical. What is the maximum number of grains which may be consumed by one bird in a day? The greatest number found in any of the above was 41, but this was in the morning, and presumably the birds would feed again in the afternoon and evening. Further, it is considered safe to assume that what is the necessary food for any one bird approximates closely to that of any other; i.e. the birds recorded with a few grains had not yet finished feeding. It is therefore possible that each bird would consume considerably more than forty grains per day. However, as a matter of interest, let us work out the hypothetical loss on a figure of only forty grains. There are 18,000-27,000 grains in 1 lb. of rice (2), which for local varieties can be taken for our purposes at 20,000 grains per pound. At a rate of forty grains, five hundred birds would eat one pound of rice in a day. The period over which birds could feed in any rice field would be about fifty days, varying with the variety, which would represent a loss of fifty pounds of rice over that period for five hundred birds. From one acre of rice an average local yield is about 1,200 lb. of husked grain, so that 50 lb. would represent a 4 per cent loss of crop to the owner of the field. That loss would be caused by a flock of 500 birds gaining their food entirely from one acre of rice during the rice season. (It will be remembered that approximately 460 birds settled in the acre under observation in Area C, in 12½ minutes.) From what was observed this loss seems more than a possibility, and it appears from this hypothetical calculation that the probable loss per acre of partially guarded rice would be at least 4 per cent. It was estimated that in Area C there were 100 acres of rice. Arguing from the above figures, to cause a general loss of 4 per cent there would have to be some 50,000 birds in the area! I regard it as highly improbable that there were so many grain-eating birds in the fields. On the other hand, the amount of grain eaten by one bird is probably considerably in excess of forty grains per diem, perhaps twice or three times as much, so that it is possible that 4 per cent represents a minimum figure of the loss of grain due to the raiding of birds, in the area observed.

This might appear a comparatively trifling loss, and be considered barely worth the natives' time to save by bird-scaring. I would anticipate, however, that there is nearly this loss under ordinary conditions of guarding the rice; the natives cannot always be on their *shambas*, and even while there they cannot keep up an endless vigil. Thus, if birds were allowed unchecked into the fields it is anticipated that losses would be very much greater than this figure, and I think this must be so, else the native would not spend as much time as he does in a thoroughly unpleasant occupation. I have known crops of sorghums practically wiped out by the uncontrolled incursions of birds, so that it is not difficult to visualize it happening in the case of rice.

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Report on A Visit to Southern India and Java

Part I.—The Coffee Industry of Southern India

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FOREWORD.

The first section of this report deals with the information obtained during a tour of six weeks through the coffee-growing districts of Southern India. A portion of the writer's time was spent with the scientific officers of the Mysore State Department of Agriculture at Bangalore and with the Coffee Scientific Officer of the United Planters' Association of Southern India (U.P.A.S.I.), who is stationed on the Mysore State Coffee Experimental Farm at Balehonnur. The remainder of the period was occupied by a tour through the main coffee-growing areas, including Mysore, Coorg, the Ouchterlony Valley, the Nilgiris, and the Shevaroys, where the writer visited some thirty-six coffee estates, representative of the different districts.

INTRODUCTION.

The date when coffee was first introduced into Southern India, probably from Abyssinia or Arabia, is unknown, but it is believed to have been brought to the town of Chikmagalur, now the centre of a large coffee-growing district of Northern Mysore, about 1600 A.D. It is known that coffee seeds were sent from India to Java in 1696, so the industry must have commenced before this date. In 1760 seeds were taken over to Brazil. Thus Southern India can claim to be the original source of supply of seed which started the great industries of Arabica coffee in both Java and Brazil.

The first coffee actually planted by a European appears to have been about 1830. From this time the acreage of land planted to coffee increased rapidly, until in the year 1875 the area was 230,000 acres. This date can be considered the peak period. About this time Leaf Disease (*Hemileia vastatrix* B. & Br.) became so serious that certain areas had to go out of cultivation, and to-day the total acreage is reduced to approximately 180,000 acres, of which some 40 per cent is owned by Indian planters. It is interesting to note that the ravages of Leaf Disease commenced in Ceylon, and gradually crept from there into the more southern coffee districts of Southern India. There are to-day few estates left where the disease is not of major importance, and had it not been for the discovery of control measures (spraying) there can be little doubt that few estates could have survived.

In addition to the acreage mentioned above, the majority of peasant farmers in the coffee-growing districts have their small plots of coffee—none exceeding ten acres in size, and many consisting of only a few trees. The crop is sold to local merchants, either on the tree or on the drying ground, and is consumed locally. These small plantations are invariably neglected, and must remain a serious source of infestation of the borer (*Xylotrechus quadripes*), the most serious pest to be met with in Southern India, to neighbouring estates. Efforts are being made to remedy this by the introduction of pest control measures, but at the present moment their success is limited owing to the lack of staff for inspection work.

The total annual crop produced is in the neighbourhood of 15,000 tons, of which almost fifty per cent is consumed locally.

In certain districts where *Coffea arabica* does not thrive there is a tendency at the present time to replant with *Coffea robusta*. In these areas it is a common sight to see *C. arabica* and *C. robusta* intermixed. Planters maintain that the production of *C. robusta* is very much cheaper, and that the difference in price on the local market is very small. It has yet to be proved, however, that *C. robusta* will fare better than *C. arabica* in these areas.

Coffee is grown in India at altitudes varying from 2,500 to 6,000 feet, and rainfall from 50 to 170 inches per annum. The optimum altitude and rainfall varies very considerably according to the different districts. For example, excellent coffee was seen growing—

(*a*) on the Bababudans in North Mysore at 3,800 feet and rainfall 60 in.;

(*b*) at Doddengooda Estate, North Mysore, at 3,800 feet and rainfall below 50 in.;

(*c*) In North Coorg at 3,500 feet and rainfall 80 in.;

(*d*) in the Ouchterlony Valley at 4,000 feet and rainfall 115 in.;

(*e*) on the Nilgiris at 6,000 feet and rainfall 70 in.;

(*f*) on the Shevaroys at 3,000 feet and rainfall 35 in.

The majority of estates are planted on sheltered steep slopes of semi-cleared jungle. On one estate visited, in the Nilgiris, the difference in altitude between the lower and higher extremity was 3,000 feet. This, of course, is exceptional, but a difference of 500 to 1,000 feet is quite general. The "facing" of the estate is an all-important factor. A northerly or easterly facing is preferred, whilst a southerly or westerly one is considered bad.

In the early stages of planting practically all coffee was planted without shade. Records during these years show that the yield per acre was considerably greater than it is to-day. Later, however, when it was discovered that shade acted as a deterrent to Leaf Disease and Borer, planters adopted a system of tree shade, which, though lowering yields, assisted in disease and pest control.

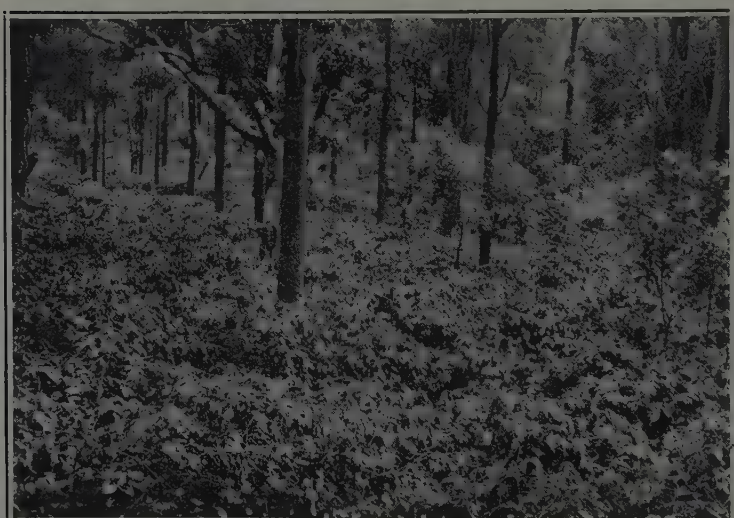
The spacing between plants is generally 6 ft. x 6 ft. Some of the older estates in the wetter districts were planted 5 ft. x 5 ft., but to-day 6 ft. x 6 ft. is usual. The bushes are allowed to produce a dense upper canopy, thus losing the majority of their lower primaries, and ultimately become umbrella-shaped. This method, which is so unsuitable to Kenya conditions, is essential in Southern India, where borer damage is severe. The dense cover on the top of the bush produces a dark shade on the stem, and thus inhibits borer damage. Owing to the lack of lower primaries, the crop-bearing area of each tree is very limited and, in spite of close planting, yields seldom exceed 7 to 8 cwt. per acre, the average for the country being between 2-3 cwt.

Very little pruning is carried out; in fact, on many estates the only pruning conducted is the removal of dead wood and handling sucker growth. "Gormandiser" growth is general, the shape of bushes on some estates presenting a peculiar picture. It is of interest to record that at least 50 per cent of the crop on one of the estates on the Bababudans, which is renowned for its London mark, is carried on gormandiser wood.

Soils.

As regards soils, Captain Windle, the author of *Modern Coffee Planting*, states: "A good forest loam is essential for a start, and I have yet to see a good coffee estate that was opened on other than forest soil. I would include bamboo

"The excellence of the coffee growing in the districts where large outcrops of rock were present was most marked."



Doddengooda Estate, North Mysore.

jungle under this heading. Rock is not a drawback; some of the finest coffee I know nestles among huge boulders of country rock, which improves the soil by weathering and conserves moisture. On the other hand, sheet rock and light-coloured stony soil are bad signs, and such land will naturally have a very poor jungle growth."

In selecting a site for a coffee estate the luxuriance of the vegetation in the forest is an all-important factor. Thin forest with little undergrowth is unlikely to be suitable for coffee-planting.

Nevertheless, whilst forest soils are of the greatest importance, the difference in the type of these soils in the various districts is most marked. The majority of soils are shallow, and even in the deeper soils it was found that the coffee plant was almost entirely surface-feeding, especially in the wetter districts. One of the most essential factors in the success of coffee-planting in Southern India is that the bush should "winter" during the dry months of January, February and March. The planter likes to see his bushes wilting during this period, as he is more certain to obtain a good flowering at blossom time. On Doddengooda Estate, in Mysore, the larger part of the soil is shallow and contains a fair proportion of gravel, but on one block it is much finer and deeper, more resembling in appearance a Kiambu soil. Mr. Kent, the owner of the estate, informed the writer that this block was the worst coffee he had, since the bushes would not "winter" properly. Presumably, in these deeper soils where rainfall is lighter, the bushes had rather deeper root systems, and did not feel the effects of drought, and consequently did not "winter" as much as those growing in the shallow soil. In this respect the Southern Indian planter is most fortunate, since it is very unusual for there to be any lack of rain during the cropping period from April to December, and after the crop is off the two months' dry weather permits the trees to go through their necessary period of "wintering".

The excellence of the coffee growing in the districts where large outcrops of rock were present was most marked. Undoubtedly, some of the best coffee seen in Southern India was growing under these conditions.

The optimum pH value for coffee in the top soil is recognized as being about 6.5. As far as the writer could gather, no analyses of the lower soils had been made.

The following table, very kindly given me by the manager of an estate in the Ouchterlony Valley, gives the analysis of ten samples of surface soil (top four inches) on which is growing some of the best coffee in the valley. The soil is a deep clayey loam, clay content being about 30 per cent:—

Sample	pH. Value	Moisture	Loss Ign. (Wet)	Loss Ign. (Dry)
1 ..	6·37	24·10	13·00	17·10
2 ..	6·21	17·10	13·60	16·40
3 ..	6·76	17·60	10·30	12·50
4 ..	6·44	17·40	14·00	18·05
5 ..	6·11	22·60	10·90	14·10
6 ..	5·69	21·05	15·70	19·90
7 ..	6·04	15·90	10·70	12·70
8 ..	7·24	20·30	13·95	17·50
9 ..	6·71	37·04	18·25	29·00
10 ..	6·44	21·80	18·05	23·05
Average	6·40	21·50	13·95	18·00

It was on the above estate that the root system of a tree was examined, and in spite of a deep and well-drained soil the system was almost entirely surface feeding. The roots did not penetrate more than four feet, and had few feeding roots. The rainfall on this estate averages approximately 115 inches per annum.

On some of the more level estates in the wetter districts, where the soils are rather heavier, it appeared that the coffee suffered from "cold feet"—that is, a waterlogged condition of the soil—for many months of the year. It is felt that a system of deep drains, in order to lower the water table, might considerably alleviate many of the problems which these conditions present.

Cultivation, etc.

It would appear that many problems connected with cultivation could be solved by a study of the period of root growth in the different districts. There is little doubt that, for the greater part, coffee in Southern India is almost entirely surface-feeding, so that damage to root systems by cultivation at the wrong time (i.e. during active root growth) of the year may have a more serious effect on the coffee plant than it is known to have in Kenya. In some soils, which appear to be waterlogged for many months of the year, the period of root growth would seem to be of short duration. Any damage by cultivation during this short period must have disastrous results. Due to this, many planters have almost entirely given up cultivation, the advisability of which is doubted. The use of the envelope fork, as practised on several estates with excellent results, would appear to lend itself to much more general use. Most estates have a large quantity of leaf mould, shade tree foliage, etc., lying on the ground, and if this was incorporated with the soil, instead of remaining on the surface, beneficial results would accrue. In addition, the aeration of the soil would be advantageous and would tend to promote a deeper and consequently larger root feeding system. With coffee planted 6 ft. x 6 ft., and with no lower primaries, the use of the *jembi* or *jembi* fork is very liable to produce bad results, inasmuch as the cultivators are apt to dig too near the stem of the bush, thus causing considerable damage to the main lateral roots.

Another practice to be found on many estates, and one which would appear to be most satisfactory, is the digging of trenches in between alternate rows of coffee, or a system of renovating pits. These methods are especially useful in the higher rainfall districts, as they assist to alleviate damage by soil erosion. The trenches are dug about 15 inches wide and about 15 to 18 inches deep, in alternate rows. They gradually silt up with leaf mould, soil, etc. After four or five years, when the original trenches are completely full, new trenches are dug in the remaining rows. Examination showed a concentrated mass of feeding roots amongst the organic material in these trenches. The principle of renovating pits is similar to that of trenching. This system appeared to be admirably suited to the Southern Indian conditions—ample rainfall and well-shaded estates—but it could not be recommended for the majority of estates in Kenya, since, in the absence of shade and with limited rainfall, the increased area of exposed soil would cause additional drying-out of the soil.

Whilst many planters believe that soil erosion is negligible, it is apparent in some districts that a considerable amount of soil is lost annually. Captain E. G. Windle informed the writer that the prevention of soil erosion is, in his opinion, of the utmost importance, and methods for its control are one of the main features of estates under his control.

Manuring.

In the early days of coffee-planting in Southern India cattle manure was plentiful, and was regularly used with excellent

results. As the area of coffee increased the supply of cattle manure was insufficient to meet the demand, and had to be replaced by applications of artificial fertilizers. To-day, very little cattle manure is used at all, but blocks of coffee which have received annual dressings are, without exception, outstanding. There is undoubtedly an increased interest being taken in the possibilities of compost making, but a shortage of bulk material is delaying progress.

Artificial manures are chiefly applied in the form of standard mixtures supplied by the local firms. The time of application depends on various circumstances, but in general it is preferred to give two dressings annually—at the time of the blossom shower, and again towards the end of the south-west monsoon, viz. April and September. Dr. Narasimha Iyengar, the Agricultural Chemist (now Director of Agriculture), in his bulletin, *The Improvement of the Coffee Industry in Mysore*, states that the coffee bean in Mysore and Coorg consists of: 2.3 per cent nitrogen, 0.4 per cent phosphoric acid, 2.0 per cent potash. Thus, taking an average crop of 600 lb. of coffee per acre, and allowing a slight excess over actual requirements, he recommends a mixture containing 30 lb. of nitrogen, 45 lb. of phosphoric acid, and 60 lb. of potash per acre.

The benefits obtained by manuring are obvious, but the writer was doubtful in some cases whether the mixtures that were being applied were the best, and therefore whether they were economical. Many factors must influence the annual requirements of the plant, and the possibility that spraying has materially altered the manurial requirements cannot be overlooked. Has "quality" been adversely affected by spraying? There were definite indications in India that this is the case. The possibility of counteracting this by revised manurial applications would appear to warrant close investigation.

Shade.

The use of the best tree shade and its control appeared to the writer to be of the utmost importance in the success of coffee-planting in Southern India. It is impossible to recommend any one or several shade trees for general use; each district has its own trees. Mixed plantings of trees are always preferred, but in young clearings one variety will predominate until the slower-growing species have become established. The intensity of shade required depends upon the district, but the evenness of the shade over the whole estate is the most important factor. The shade should be pruned well up over the top of the coffee bushes, and regulated to produce even density throughout. It is very easy to state the necessary requirements, but it is an extremely difficult matter to attain this in practice. It would not be exaggerating to say that the successful planter spends as much time on the attention to his shade tree as he does to the coffee underneath it. As already mentioned, shade is a deterrent to leaf disease, and is essential for the control of borer; thus an estate with well-regulated shade seldom suffers severely, whilst estates with badly neglected shade—bare, unshaded patches, etc.—are seldom without trouble.

It has been stated that each district has its own shade trees—a good tree in one area most probably being bad in another. A few of the more important trees used in different districts are:—

(*a*) *Ficus infectoria.*—This is a decidu- tree of medium height, with wide-spreading and well-provided aerial roots. A late coffee planter of Southern India, Mr. Graham

Anderson, states: "This tree, with its long, dark green, glossy leaves, may be said to be one of the finest for shade purposes in the forests of Mysore." It certainly appeared an excellent tree in certain parts of North Mysore with moderately heavy rainfall.

(*b*) *Ficus glomerata*.—This is another very desirable tree. Mr. Graham Anderson states: "It is generally allowed to be the very best shade tree for coffee estates, and is consequently invariably preserved. It is easily propagated from seed and small cuttings. It is almost destitute of leaves in the monsoon, but in the hot weather it is clothed in a rich, glistening foliage. It is admirably suited for coffee, which flourishes under its cool and most desirable protection." Excellent in Mysore and Coorg.

(*c*) *Ficus Tjakela*,

(*d*) *Ficus mysorensis*.

Two more trees of the *Ficus* sp., both of which are liked in Mysore.

(*e*) *Dalbergia latifolia*.—Produces an excellent shade in some districts.

(*f*) *Pterocarpus Marsupium*.—Another tree very much liked in some parts of Mysore.

(*g*) *Terminalia belerica*.—Another very popular tree in several districts. Grows well in Mysore at 3,800 ft. with rainfall of 50 in.

(*h*) *Bischofia javanica*.—This tree is also considered a good tree in Mysore at 3,800 ft. with a rainfall of 50 in.

(*i*) *Acrocarpus fraxinifolius*.—Not very common, but where the old forest trees have been left the coffee thrives under them.

(*j*) *Albizzia Lebek*.

(*k*) *Albizzia stipulata*.

Both trees grow well and coffee thrives under them. Unfortunately they tend to shed their foliage during the hot weather.

(*l*) *Artocarpus integrifolia* (the Jak Tree).—This provides an excellent shade for coffee on the Nilgiris (altitude 3,000 to 6,000 ft., rainfall 50 to 75 in.) and on the Shevaroys (altitude 2,800 to 4,000 ft., rainfall 55 to 60 in.).

(*m*) *Streblus asper*.—A popular tree in certain areas, but not liked in many.

(*n*) *Erythrina lithosperma*.—A quick-growing tree, frequently planted in new clearings as a temporary shade. Would appear to be quite a useful semi-permanent shade on Nilgiris and Shevaroys.

(*o*) *Grevillea robusta*.—This tree is almost always planted as a temporary shade in young clearings, and serves a very useful purpose. In Mysore and Coorg it is seldom allowed to remain for more than 15 years, as after this it affects the coffee. On the Nilgiris and Shevaroys, although planters state that they do not like the tree when old, coffee may be found growing under very old Grevillea shade without any apparent harmful results.

Spraying.

It may be said that the use of Bordeaux mixture as a control spray against Leaf Disease has saved many estates from total extinction. Interest was aroused as to the possibilities of Bordeaux mixture when Dr. Coleman discovered that it was an effective means of control against the *Phytophthora* disease of areca nut in 1908. Attention was turned to its use as

a control against Leaf Disease in coffee; progress was slow in the initial stages, but it is of interest to note that an authority states that the area of coffee sprayed increased from 300 acres in 1929 to 18,000-20,000 acres in 1930 in Mysore State alone. In recent years considerable attention has been given to spraying and the subjects closely related thereto by Mr. Wilson Mayne, an account of whose work will be found later in this report.

To-day there are few successful planters who do not spray, although there still remains an occasional isolated estate which does not suffer sufficiently from the disease to warrant the expense incurred. Unfortunately, these are few.

After several years of experience, the planter has now systematized his spraying operations, and each spraying unit is run in a very efficient manner. The biggest problem to be confronted is that of water, which in many cases has to be carried considerable distances along the narrow paths on the heads of coolies. Some planters are now laying a system of water-pipes over their estates, which is speeding up spraying operations. Different types of pumps are used, individual planters having their own opinions as to which are the best. Power pumps are seldom seen, since it is usually found that the cost of hand labour for pumping is less than the cost of the petrol, etc., used. It is found that, in general, power pumps will not maintain the correct pressure with the number of nozzles they are advertised to deliver from; consequently they become expensive units. A new German power pump recently introduced is commanding keen interest on account of its low price and outstanding performance. Unfortunately, the writer was unable to see it at work, but was informed that it had already been given a good trial, with excellent results. Of all the pumps in use, Mr. Mayne states that he still believes the Drake and Fletcher "Headland" pump to be the most serviceable. These pumps have been in continuous use on the experimental farm for the past three to four years without giving any trouble. The new Craven "Headland" pump is now receiving trial at the farm, with very satisfactory results. The price is very much in its favour.

Factory Management.

The writer was not impressed with the primitive methods employed in the majority of factories. Fermentation is carried out in general under dirty conditions. It is apparent that very little attention has been given to this aspect of coffee culture. There is, however, a tendency to-day to improve methods, and the appointment of a biochemist signifies that the matter is to have the attention it justifies.

The coffee parchment is never completely dried out on the estate. It is dried until it contains about 30 per cent moisture, and is then bagged and forwarded to the curers. The curers, situated mainly at the coast, finish the drying process on their own barbecues. They insist on completing the drying themselves, so that the coffee may be warm when it is cleaned, maintaining that better work is done under these conditions. Artificial driers are seldom found, and are never used at the curing works.

A special word of praise must be given to the method of garbling or hand-picking the coffee by the Southern Indian curers. Every planter speaks highly of the efficient garbling process, and there is no doubt that the evenness and lack of inferior beans in the finished sample speaks highly for the method

adopted. Hand-pickers in some of the works have been trained and employed for many years by the same firm, and their work has now reached a high standard of efficiency. The importance of the garbling process cannot be overestimated, and Kenya might do well to follow the example set by India in this respect.

Research Work.

The Mysore Coffee Experimental Farm at Balehonnur.

The station, which was opened in December, 1926, owes its existence to Dr. Leslie C. Coleman, M.A., Ph.D., C.I.E., the Director of Agriculture, Mysore, at that time.

The farm consists of 290 acres of land, of which 120 acres are under coffee—80 acres being coffee about thirty years of age, and 40 acres planted since 1928. The greater part of the remaining unplanted area comprises virgin jungle, which is fit for development when required. It is situated about five miles from Balehonnur and approximately 200 miles from Bangalore, the headquarters of the scientific officers of the Agricultural Department. Elevation ranges round 2,890 feet above sea-level, and rainfall averages about 100 inches per annum, of which 80 per cent is precipitated during the months of June, July, August and September.

Funds for the upkeep of the station are obtained from:—

(i) A cess of two annas per acre on each acre of coffee land on estates of 25 acres and over.

(ii) A Government grant of an amount equal to that raised by the coffee cess.

(iii) Realizations from the farm produce.

The total income has ranged from Rs. 36,000 and Rs. 45,000 per year (£2,700-£3,375), and the expenditure has been limited to the amount shown as receipts.

The organization and administration of the station is under the direction of the Director of Agriculture, Mysore, who is assisted by an advisory board, consisting of five planters, of whom three represent planting associations, and the other two are nominated.

The station staff includes the farm manager, assistant farm manager, plant-breeding inspector, a grafter, laboratory assistant, two mechanics, a clerk, and a labour force of 110-120 coolies. In addition, Mr. W. W. Mayne, the Coffee Scientific Officer of the United Planters' Association of Southern India, resides on the station, and carries out research work on coffee problems in the laboratory in co-operation with the farm staff.

The work on the station consists of seven main lines:—

(*a*) Spraying.

(*b*) Laboratory work on plant diseases.

(*c*) Manurial trials.

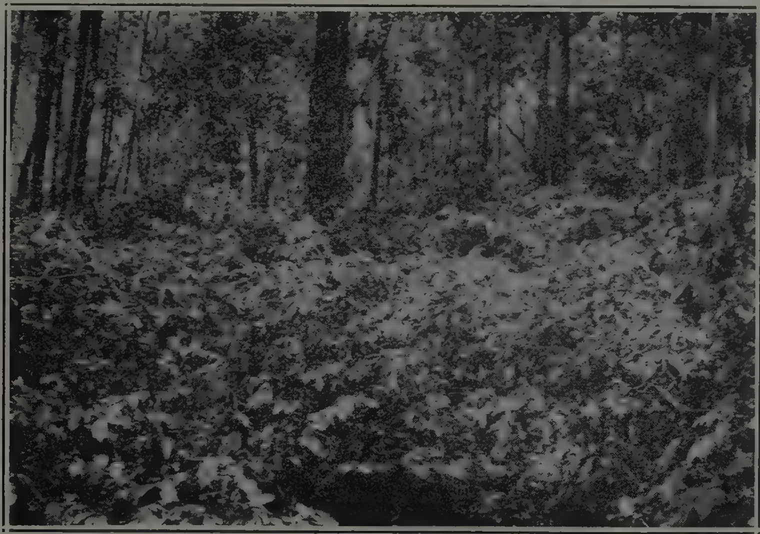
(*d*) Breeding.

(*e*) Vegetative propagation.

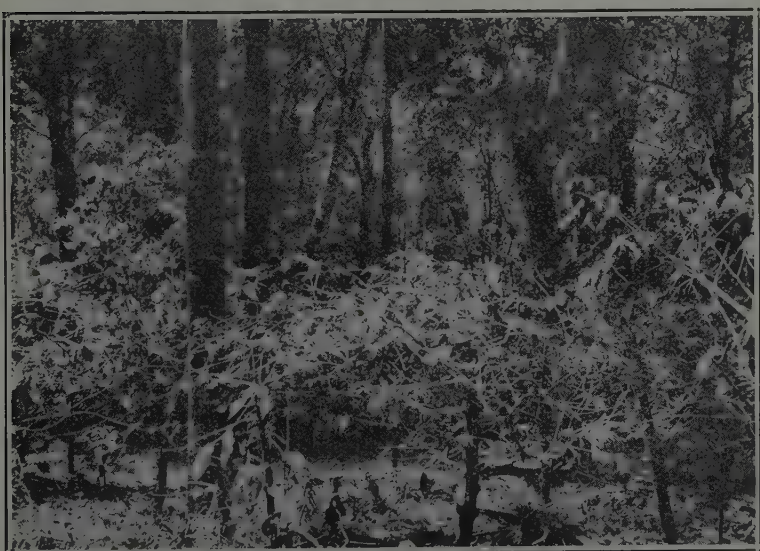
(*f*) Trials of green manures.

(*g*) General agricultural practices.

(*a*) *and* (*b*) *Spraying, and Laboratory Work on Plant Diseases.*—The work being carried out on spraying and on plant diseases is so closely linked in a number of cases that the two subjects must of necessity be discussed together. When it is realized that spraying has a direct effect on Leaf Disease (*Hemileia vastatrix*) and Black Rot (*Corticium koleroga*), and, in addition, an indirect effect on Dieback, with which *Colletotrichum coffeanum* is regularly associated, and the Borer (*Xylotrechus quadripes*), the importance of the work conducted on these investigations cannot be overestimated.



Mysore Government Coffee Experiment Station : Sprayed Plot.



Mysore Government Coffee Experiment Station : Unsprayed Plot.

The bulletin published by the Mysore Coffee Experiment Station—Bulletin No. 9 (1933)—entitled *Spraying of Coffee in South India*, by W. Wilson Mayne, B.Sc., M. J. Narasimhan, B.A., and K. H. Streenivasan, M.A., B.Sc. (Edin.), details fully a mass of most interesting observations discovered during the researches.

Leaf Disease.—With regard to the work conducted, using Bordeaux mixture as a control for Leaf Disease, it is openly admitted by the officers engaged on this work that the results obtained leave much to be desired. It is not reckoned that spraying at the moment is more than 50-60 per cent effective. Nevertheless, the effect of spraying is very apparent, and the results obtained fully justify its use and also warrant further expenditure for research work. The results obtained on one estate, which is by no means in the worst district, are typical. They show that for three years before spraying the average crop obtained was 80 tons, whilst for the three years since spraying has been in practice the average crop has risen to 117 tons—an increase of nearly 50 per cent.

The Coffee Scientific Officer regards the time of application of the spray as the factor which limits success or otherwise. Observations made during the tour certainly confirmed this. It would appear that it is impossible to lay down any definite time, since this may vary from year to year, according to the climatic conditions prevailing. That a pre-monsoon spray is essential is proved, but the actual time at which this should be applied still remains doubtful, and it is probable that under certain conditions, if practicable, it would be beneficial to carry out two sprays between the time of the blossom showers or earlier rains and the period of heavy monsoon. As Bordeaux mixture is only a protective, the application should be made before the outbreak of the disease, or, in other words, before severe infection has taken place, and when the trees are carrying the largest amount of new leaf growth. Unfortunately, the times at which these two conditions occur do not always correspond, with the result that a severe outbreak of the disease may prevail later in the year.

A second, post-monsoon, spray has been found beneficial, but it is still doubtful whether it is an economic proposition. In one district visited, however, it would appear that this spray is very important, and that its time of application is of great consequence. Here climatic conditions are very different from those in the experimental station, and it may be that the so-called post-monsoon spray is that which corresponds to the pre-monsoon spray on the station.

Up to the present, all the work that has been conducted on the strength of the spray mixture has shown that a ½ per cent mixture is as effective as a 1 per cent, and the former is used entirely for all experimental work and in field practice on the station. On one or two estates visited full strength mixtures are still used, but this is becoming rare.

The usefulness of adhesives is doubted. Whilst it is believed that the addition of adhesives does tend to increase the "staying-on" power of the spray, it is doubted whether the additional cost of the adhesive is economical. In this respect one cannot do better than quote an extract from the Coffee Scientific Officer's Annual Report for 1934-35. He says: "The difficulty of giving advice on the use of adhesives is great. Thus, even if a small gain is likely from the use of adhesives, it is possible the money spent might be better employed. For example, assuming the cost of an adhesive works out at R. 1 per acre, the omission of the ad-

hesive on a 200-acre estate, assuming two sprays a years, would be sufficient for the purpose of another sprayer. The improvement in spraying at the most favourable times possible with an extra machine is likely, in my opinion, to outweigh any slight decrease in efficiency resulting from the omission of an adhesive." This again shows the importance that the Coffee Scientific Officer pays to the time of spraying.

Black Rot (*Corticium koleroga*), causing a blackening of affected leaves, twigs and berries, occurs in the heavy rainfall areas. On estates in the drier areas the attack is not serious. Due to the fact that the fungus lives in the early stages on the surface of the leaves, twigs and berries, a complete control of the disease can be obtained by one efficient pre-monsoon spray. This was most marked on the sprayed and control unsprayed plots on the experimental farm. Provided spraying is carried out, the disease is of no consequence.

Dieback, from which *Colletotrichum coffeanum* is always isolated, is found in Southern India to be a debility disease, brought about by the loss of leaf due to attacks of Leaf Disease and other causes. A close study of this disease was made by the writer, together with the Coffee Scientific Officer, who accompanied him on part of the tour, and it was found that in no case were branches attacked which carried several pairs of leaves. Further, the dieback on the branch invariably commenced at the point where defoliation had taken place. If the tip leaves were lost, dieback would occur from the tip along the branch until older, healthy leaves were reached. If the older leaves, say midway along the branch, were lost, the dieback would commence at this point, spreading possibly both ways. Where trees were regularly sprayed, with consequent retention of leaf, and cultural practices were good, dieback was never to be found, whilst unsprayed, debilitated trees often showed severe symptoms.

Borer (*Xylotrechus quadripes*).—The white borer is by far the most severe insect pest of coffee in Southern India. Its effective control is most difficult, but much can be done by maintaining a heavy overhead shade. In this respect, spraying again plays an important role. Sprayed trees, by maintaining their leafage, have their stems densely shaded, which is unfavourable for the egg-laying habits of the female. That spraying is undoubtedly of great value is shown by results obtained at the experimental station. Over a period of two years the mean percentage of trees removed due to borer damage on the Bordeaux sprayed plots was 2.2, whilst on the control unsprayed plots the mean percentage was 12.3.

Other methods of control for this most serious pest are adopted as well as spraying. The importance of good, even tree shade cannot be over-emphasized. On many estates the stems of the trees are rubbed with gunny bags or coco-nut shells in order to remove the eggs. The entomologist has recently found that painting the stems with an oil tar distillate gives good results, but experiments conducted have not yet proceeded far enough for any definite recommendations.

From the above it will be seen that spraying has a very direct bearing on the control of four of the major pests and diseases in Southern India.

Amongst the other diseases and pests to be found affecting coffee, the Green Bug (*Coccus viridis*) and the Brown Bug (*Saissetia hemispherica*) are the most important. These are to be found in the drier districts, and in some cases cause

severe loss of crop. Fish-oil resin soap, used as a spray, is found to be effective if continually applied. It would appear that the attending ant plays an important part in the life-history of these two pests, and much might be done by its eradication, a policy which is being adopted on some estates.

Nematode worms cause trouble in some areas, and investigations are being conducted, without, it is feared, very encouraging results to date.

Stump Rot (*Fomes noxius*) and Black Bean (or Spotted Bean) are of minor importance, the latter being seasonal.

(*c*) *Manurial Trials.*—Whilst it is generally recognized in India that manuring is essential, the results obtained from experimental work conducted have been extremely disappointing. A large area of the old coffee at the experimental station has been devoted to manurial trials. The main experiment has been in progress since the station was started in 1926, and practically no results have been obtained to date. Data collected have tended to show that, of the nitrogenous manures, the best to use is sulphate of ammonia; of the phosphatic manures, super-phosphate; whilst there is nothing to choose between sulphate and muriate of potash as potassic manures. Owing to the difficulties of obtaining the material, and the further difficulties of application due to close planting, no trials with organic bulk manures have been tested. It is intended to consider the matter more fully in the near future. Although no experimental figures have been obtained to justify the application of fertilizers, it is very apparent on a number of estates that an apapplication is most beneficial. This is most striking on estates that abandoned their manuring programme a few years ago in favour of spraying. Crop yields rose for the first two years, but now there is a sharp decline, undoubtedly due to manurial deficiencies.

(*d*) *Breeding and Selection, and* (*e*) *Vegetative Propagation.*—Whilst the immediate needs of the planter are being cared for, perhaps the line of work recognized by the station to be of the greatest value in the future is that of breeding and selection, and the propagation of such material by vegetative means. Although little has been heard of this branch of work in Southern India, the writer was struck by the amount of work which is being done on a sound and systematic basis. The main work is being carried out by Mr. Mayne, in an endeavour to obtain selections resistant to Leaf Disease. This work is proceeding apace, and he has already been successful in finding trees which are resistant to both physiologic forms of the disease. Selfing and crossing will, it is believed, produce types of good quality and resistance. In addition to the work on resistance to Leaf Disease, the farmer manager, together with his plant-breeder and propagator, is doing valuable work by the selection and selfing of hybrids or mutations showing special characters, and by carrying out a large number of crosses between these several types. Grafting is already becoming a general practice; much use of this method of propagation is being made for working up clones of the different selections. It is also being adopted in estate practice for improving the yield of existing plantations by top grafting with grafts from high-yielding trees. The ordinary wedge or cleft graft, as recommended in Kenya, is used. All grafts are covered with paraffin-waxed paper covers. It has been found that the best months of the year for grafting are March to July (early south-west monsoon), when 90 per cent of success is obtained; if grafting is done during other

months of the year the success may be as low as 20 to 25 per cent.

The striking of cuttings has not been so successful; a certain percentage of hardwood cuttings planted in the open nurseries have struck, but their subsequent growth has been disappointing. This corresponds to our findings in Kenya, and it will be of interest to learn what success is obtained from the softwood cuttings which are now being struck in propagators.

When the selection work was commenced, seed from more than 300 different individual trees was sent to the station by planters. A large number of seedlings from these proved of little value in the nurseries, and were discarded at once. Others showing more promise were planted out, but many of them were also discarded later on. Of the remainder, some are being bred up by means of selfing and selection; others are being crossed with fixed types, such as Kent's Arabica. Most of the selections that remain are strong and vigorous, and show much resistance to Leaf Disease, but they are shy bearers, and contain a high percentage of malformed beans. Amongst these hybrids there is a definite tendency to male sterility, and even when crossed with a self-pollinated variety the progeny have continued to be male sterile, and for this reason have had to be discarded.

(*f*) *Green Manure Trials.*—Owing to the close planting of coffee, it is not possible to establish green manures between bushes. The importance of a soil cover to prevent wash and improve fertility during the first few years after planting is appreciated, and trials of a number of possible crops are in progress. Another use for these crops is when areas of old coffee have had to be removed due to borer damage. If a high-growing green manure crop is grown with the young coffee when replanted, the dense shade produced will assist in preventing fresh borer attack. A large number of possible crops have been tried, the most promising of which are *Tephrosia candida, Crotalaria anagyroides, Crotalaria usaramoensis, Indigofera endecaphylla,* and *Vigna oligosperma.*

(*g*) *General Agricultural Practices.*—The work falling under this heading consists chiefly of experiments covering pruning and cultivation, but the work has not been proceeding sufficiently long for any definite conclusions to be obtained. The planting of young plants in baskets is largely practised in Southern India, as it is stated that unless supplies are planted by this method success is seldom obtained. By planting in baskets the young plants appear to come away quickly, and are not affected by the old trees surrounding them. Baskets are liable to rot quickly, and are often in a decayed state when taken from the nursery. It has been found recently that treating the baskets with copper sulphate preserves them and prevents this speedy rotting.

Ramie, Rhea-fibre or China Grass (*Boehmeria nivea*)

Department of Agriculture, Kenya.

Ramie is a perennial shrub, five to seven feet high, with large, heart-shaped, crenate, hairy leaves — greyish-white beneath—which is indigenous to parts of tropical and sub-tropical Asia, and is cultivated in China, Japan and Formosa. During the last few years this fibre plant has been grown on some scale in Trans-Caucasia, while experimental plantings have been made in Tanganyika and Kenya. The inner bark of the stem constitutes the "China grass" from which is prepared the ramie fibre of commerce, which is pure white, of silky lustre, and is used in the manufacture of fine linen, gas mantles, upholstery, and other purposes.

This plant, which is of the nettle family (*Urticaceae*), was introduced into Kenya in 1905 by the late Captain Nevison and Le Vicomte de Kegarion. Captain Nevison carried on the production of ramie for some years until the beginning of the War, when, owing to the fact that his market was in Germany, he found it impossible to carry on. The use of this excellent fibre was hampered for many years by the absence of a method for removal of the mucilaginous material from the "ribbons" of the China grass. New processes have recently been patented which open up a further vista of possibilities for the use of this attractive and hardwearing fibre.

The plant requires a rich, deep, friable and well-drained loamy soil, and is probably most suited to chocolate forest soils such as are found in Upper Kiambu and Limuru. Humid conditions are required by the plant, and a rainfall of at least 50 in. is desirable. A marked dry season is very detrimental to the growth of the plant, and, in fact, a whole year's crop may be lost following a severe drought. The planting of efficient windbreaks every 250 or 300 yards would assist in the conservation of moisture in a ramie plantation. Like nettles, ramie will grow well in partial shade, but this is not necessary once the plants are established. It must be emphasized that not only does the crop require a well-distributed rainfall, but, since it is a type of plant which grows on soils which have been recently forest, it is essential that the soil shall be a rich one. It is an exhausting crop, and heavy manuring and good cultivation are essential. If these matters are attended to it should not be necessary to replant for six or seven years.

Propagation and Planting.

Ramie may be propagated from seed, by layering, by cuttings, or by division of the roots—the last method being preferable. The soil should be ploughed deeply and a good tilth ensured. One authority recommends a spacing of two feet between rows and one foot in the row; another three feet between the rows and two feet between plants in the row. Apparently success has not always attended the raising of plants from seed, but the following is based on a memorandum written by the late Mr. J. Stocker, an early Kenya settler, who was very interested in the prospects of this crop:—

(i) The seedlings are grown in seed boxes, prepared as follows: The boxes are filled with good sifted soil, placed on a thin layer of leaves; the seed is thinly sprinkled on top of the soil, and lightly covered with fine sand; the seed boxes should be in a warm, protected place, and the soil should be moistened occasionally by setting the bottom of the boxes in water until the soil is moist throughout.

(ii) The first shoots should appear in seven to ten days, but the boxes should not be weeded until it is evident which are

the Ramie plants and which are the weeds.

(iii) The plants should be transplanted in the nursery when three inches high, in rows two feet apart and at a distance of one foot apart between the plants.

(iv) In a year from the time of the establishment of the nurseries sufficient cuttings should be available for planting ten times the area of the nurseries.

Mr. Stocker recommended that the field into which the cuttings were to be planted should be ploughed with a ridging plough of 5 in. deep, with the furrows 12 in. apart. The full length canes are laid in the furrows, each cane overlapping its predecessor by half its length. The furrows are filled in by cross harrowing with a tooth-harrow turned on its back. A worker on the crop in Punjab some forty years ago advocated the following method of raising ramie from cuttings:—

"The stems should be spring-grown ones, allowed to ripen well and not cut until duly ripe. Then divide the ripened portion of the stem where the cuticle has turned fully brown into short lengths, each including three eyes or buds. Cut a quarter of an inch below the bottom bud and as much above the top one, and plant with the centre bud level with the surface. If the weather is damp and cloudy they will readily strike root, otherwise they will require shading for a week or ten days, the soil being kept moist. As with seedlings, I find a foot apart every way the most advantageous distance, as very few shoots are thrown up the first year."

The roots remaining in the nurseries may then be lifted and cut up and the pieces planted one foot apart in the furrows and covered in the same manner.

Harvesting.

It is desired to obtain straight, clean, unbranching stems. A small crop may be obtained about ten months after cutting, and subsequently two or three cuttings per annum may be made; in good years, as mny as four cuttings may be taken. The crop should increase in vigour and closeness with each succeeding years, and on good soil the canes should average from four feet in length at maturity, that is, when they are brown for one-third of their length; obviously, in order to obtain long, thin, unbranched stems, a good and close stand of plants is necessary. The fibre is not separated from the stems by retting, as in the case of other fibres, but is removed entirely by hand or by a decorticating machine. It is then subjected to a chemical process of "degumming" in order to remove the gummy substances present.

The following is an extract from a note by Mr. M. N. Wight, District Agricultural Officer, Tanganyika Territory, on the separation of Ramie ribbons:—

"Sun-drying the freshly stripped bark or ramie greatly reduces the strength of the fibre; shade-drying, on the other hand, gives a softer sample with no loss of strength. Retting is not advised; leaving the stems in water for two to three days also weakens the fibre, and, in any case, does not ease stripping.

"The bark comes off very much more easily and in broader pieces if stripped from the top of the stem downwards than if taken from the bottom upwards; this applies in particular to the older stems. I find that one boy can, having the trimmed stems ready at his side, strip about 2 kg. (green weight) of bark per hour.

"To produce a very much finer sample, the bark can be scraped very easily by a native. This is done by laying the fresh bark across the knee and scraping with a fairy sharp small knife. One boy scraping can easily keep up with one stripper. Scraping gives an approximate reduction of 50 per cent in the dry weight of the sample."

It is stated by the Agricultural Department, Tanganyika Territory, that the cost of clearing, planting ramie and bringing it to the first cutting varies from £2 to £5 per acre; the cost of cutting, stripping the ribbons by hand and shade-drying is £1-15-0 to £2 per ton; a yield

of one ton per acre may be obtained under favourable conditions: thus the cost on the farm (exclusive of the cost of management) should be about £7 per ton. It is not necessary for the ribbons to be absolutely dry before baling, since they will not ferment readily.

Small machines are available for removing the cortex. The "Miranda" is a decorticating machine which is manufactured by Messrs. A. Faure and Co., Limoges, France. This costs 5,300 frs. (approx. £71) or 5,860 frs. (approx. £78) including several spare parts; an outfit including one "Miranda" machine, 2 h.p. petrol engine, and one truck, costs 9,100 frs. (approx. £121)—in all cases f.o.b. French port. It is stated that this machine will turn out 275 lb. of dry fibre in nine hours.

Yield and Future Prospects.

The annual yield is estimated to be about 20 tons of canes per acre, giving about one ton of dry ribbons, which would furnish about 50 per cent of degummed fibre, or *filasse*. There appears to be a considerable market for these ribbons and one manufacturer who is interested in the product states that he is prepared to purchase up to 2,000 tons of decorticated (cleaned) ramie ribbons at a price of from £20 to £22 per ton, ci.f. London.

At present, ramie is being grown experimentally at Nyeri and Kisii by the Agricultural Department, and at Jamji Estate at Kericho. Further trials are to be made at Embu and Fort Hall with a small amount of planting material which is being received from Amani.

A sample of China grass grown at Nyeri, which was sent to England for preparation and commercial examination, was reported upon as follows:—

"I am glad to say that I consider the Kenya product much superior to the imported China grass (enclosing sample for your perusal). The fibre is considerably finer in diameter than the Chinese product, and this should prove *the very thing* that the trade was endeavouring to obtain for years. The large diameter has hitherto been one of the drawbacks, owing to the difficulty in spinning fine counts, being brittle and firm, whereas the finer fibre will make it possible to spin fine counts not so brittle and a softer product."

If future trials of this crop in Kenya should prove to be an economic success, it is possible that a factory might be established for the preparation of the fibre in Kenya, so that the expense of the freight on the raw material would be eliminated.

(*Continued from page* 29)

Soil Erosion:

base terraces in pasture land may be made by a plough and, in the absence of any grading implements, finished off by hand. It may or may not be found necessary to interrupt ridges made on pasture land by periodical openings in the ridge which will permit of the outflow of any excessive amount of storm water. As a rule, if very heavy rains are expected, and the soil is very poor and lacks the power of absorbing water readily, it will be found better to make the ridges on a slight grade rather than to leave openings in level contour banks.

Note.—This level has been given a thorough trial at the Plant Breeding Station, Njoro, and has been found most successful. The Agricultural Officer, Njoro, states that it costs about Sh. 5 to make.

A Home-made Terracing Implement

By C. D. HILL.

The ordinary type of ditcher did not prove very satisfactory for the work of constructing terraces, as it was found difficult to control the depth and to hold the implement to its work.

For this reason it was decided to convert an ordinary disc plough body for the purpose, the advantages being that depth of cut, angle of blade and steering would all be more easily controlled; and thus it would be possible to mount the bank of the terrace and so increase its height. The implement would also be sufficiently heavy to hold to its work, and yet draught would not be too heavy, since the implement is on wheels.

The converted plough has proved a great success, and the work done by it has proved in every way satisfactory.

CONSTRUCTION OF IMPLEMENT.

The materials used were as follows:—

- 3-furrow Hercules plough with discs removed.
- A few feet of 7/8 in. round iron for U bolts.
- 1 spare centre beam for 3-furrow plough.
- A few square feet of 1/16 or 1/8 in. sheet metal.
- 1 old motor rim.
- 1 old railway sleeper (*see* Fig. 1).

Nearly all the above are to be found on the ordinary farm.

The railway sleeper was used as the blade, being placed in a trench fire and beaten out with a heavy hammer into the shape of a grader blade, leaving the pointed end curved in a forward direction to give added rigidity for cutting hard land. This operation requires a good deal of work, as the steel is exceptionally tough, an advantage which becomes very apparent when the implement is in use. A certain amount of curve from top to bottom, not lengthwise, should be given to the blade, as this tends to roll the soil like a true grader.

A spare middle beam for a Hercules plough was then obtained, turned round and placed against and in front of the centre beam of the plough from which the disc-holders had been removed, so that the end of the spare beam, that should hold the disc-holder, was lying against the frame of the plough, making an extension (*see* Fig. 1).

It was clamped in this position by two 7/8 in. U bolts and plates, which were long enough to enclose all the beams in the frame, and also fixed with two more U bolts round the two beams and through the disc-holder. These U bolts had to be specially made, as the standards for clamping the disc-holders are not sufficiently long. Another disc-holder was then clamped with the standard U bolts to the end of the extension beam.

The grader blade was now drilled and bolted to the two disc-holders, each with three bolts; each disc-holder being turned until one hole was directly at the bottom before bolting on the blade. Washers or small lengths of piping must be used on the upper two holes between the blade and disc-holder in order to set the blade approximately vertical, otherwise it would assume the angles normally taken by the disc. This angle can of course always be altered as is found convenient by altering the amount or size of these washers.

It was further found necessary to rivet a piece of 1/16 in. sheet metal to the

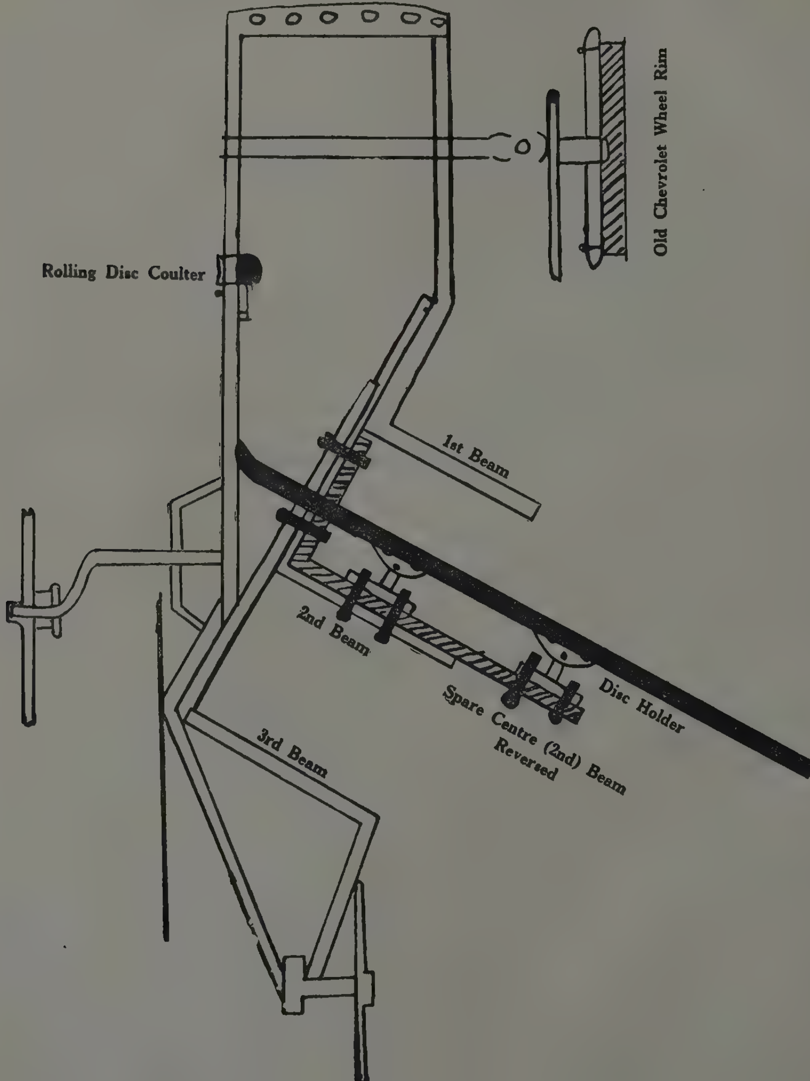


FIG. 1
Hercules Plough Converted to Grader

top of the blade so as to prevent soil being pushed over the top when working deeply.

The front wheel of the plough tended to sink in, thereby causing the implement to work too deeply and the blade gathered more soil than it could handle. In order to obviate this, an old Chevrolet car spare tyre rim was fixed to the front wheel by drilling 5/16 in. holes through its spokes and fitting to the rim brackets suitable to the inside of the wheel. A difficulty commonly experienced when working any kind of grader is that if there is a good deal of straw or other trash on the land it tends to gather up and prevent the implement from working properly. This difficulty was overcome by bolting the blade to the disc-holders so that the front edge is directly in line with the left-hand frame member of the plough. A small rolling coulter is then fitted to the frame member and this cuts through any trashy material before the edge of the blade meets it. This position of the blade also places the rear wheel of the plough against the furrow made by the front of the blade and thus ensures that the implement keeps to its work.

Working the Implement.

On old fields it was found unnecessary to plough the survey line of the ridge first. The grader will cut its own soil, and, in fact, works better if allowed to do so, as the blade scours and pushes the soil better.

The land lever should be put hard in and the two furrow levers only slightly, thus giving the whole implement a tilt, so that the front end of the blade will cut deeply into the soil and the rear end will be tilted only slightly, so that the blade can free itself of soil easily and the soil escapes in a wedge shape.

To locate the ridge truly on the survey line, it is advisable to do the first few trips with a tractor, afterwards using oxen, as they consolidate the ridge with their feet as it is built.

After a number of trips have been concluded, each cutting new soil, it is advisable to take the implement to the top of the ridge, so as to increase its height, as the centre of the ridge should be graded to its full height early in the process of construcion.

The grader is not reversible, but this does not matter when building ridges from both sides, which is the commonly accepted practice. Care must also be exercised in turning. The implement has further uses as a road grader, and can be used for digging shallow trenches.

The only drawback to the grader lies in the fact that when working on a heavy soil under wet conditions, soil and weeds are liable to ball up between the blade and the front beam, but on the lighter and more erodable types of soil this difficulty should not arise. At any rate it could probably be overcome by mounting the blade on strong brackets on the disc-holders, thus bringing it in line with, or a trifle in front of, the beam.

The cost of making the implement is negligible as compared with the cost of a purchased grader, and provided the old plough is available on the farm is probably even less than that of the wooden V-drag described in a previous article (*East African Agricultural Journal*, Vol. I, No. 4, p. 311).

Protection from Mosquito Bites in Outdoor Gatherings*

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The problem of temporarily ridding a small area of adult mosquitoes where a large number of people could comfortably enjoy a summer evening has often presented itself. Such places may vary in area from a few square yards to several acres, and may consist of a well-cared-for lawn, shrubs, flowers, trees and other valuable vegetation which must not be injured. It is obvious that in order to eliminate mosquitoes the area must be treated in such a way those those on the wing or resting on the grass within the area are killed or incapacitated, while those outside of the treated area are repelled.

The New Jersey mosquito larvacide contains a light petroleum oil and pyrethrum, and has been extensively applied during the last three years in exterminating larvæ and pupæ in waters without injury to fish, waterfowl and vegetation. Pyrethrum was shown to be toxic as well as repellent to adult mosquitoes. Furthermore, it has been observed by many mosquito workers that the female mosquito will not lay eggs on water covered with kerosene or fuel oil. Evidently light petroleum oil also possesses repellency against the adult mosquito. In view of the above properties, it was conjectured that the larvacide, applied as a diluted spray over the entire area where the meeting takes place, might prove effective and economical for temporary protection.

Accordingly experiments were conducted with various dilutions of this larvacide. Up to date the writer has records of some 50 tests on areas ranging from a few square yards to five acres, involving evening gatherings of from 10 to 2,000 people. The results indicate that it is quite possible and economical partially or completely to protect an outdoor gathering, such as carnivals, picnics, open-air theatres, lawn parties, etc., from mosquito annoyance by spraying the area with the larvacide diluted 1 : 10 or 1 : 12 with water without any appreciable injury to vegetation and without discomfort to the audience. The spray is applied in the form of a fine fog, covering the grass, ground, shrubs, as well as throughout the air.

Directions for Spraying.—About half an hour before the gathering takes place the area is completely sprayed with the larvacide diluted 1 : 10 or 1 : 12, that is, one part of the larvacide is mixed with 10 or 12 parts of water. The spraying is done with a power sprayer, capable of developing a pressure of 100 pounds or more per square inch, and equipped with a spray gun. Before mixing with water the concentrated stock larvacide should be well shaken. Also the diluted spray should be frequently stirred or agitated in order to secure uniform distribution throughout the spraying operation. The spray is applied in the form of a fine fog directly to the grass, grounds, tents, trees, shrubs, etc. Then the stream is directed upward so as to saturate the atmosphere with the fog. At no time should a coarse spray be applied, since it is unnecessary and may injure vegetation. The grounds for about 20 feet outside the area should also be thoroughly fogged, especially when tall grass, shrubs, woodland, and other vegetation are present offering a hiding-place from which adult female

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mosquitoes may issue suddenly at dusk in large numbers. If the area has been thoroughly fogged, one treatment may suffice for two hours or even the rest of the evening. If mosquitoes become bothersome later in the evening, the area on the outside of the "gathering" grounds should again be fogged, directing the stream primarily upward and towards the ground to be protected. This outside fogging may be repeated again if necessary. On small areas, such as backyards, private lawns, etc., a knapsack sprayer or bucket pump, capable of producing a fog spray of 10 to 15 feet high, can be used.

In one experiment a five-acre fairground, surrounded with shrubs and woodland, was sprayed five evenings in succession. On the night before spraying was started, the mosquitoes were so numerous and vicious that many people were forced to leave the grounds about 9 p.m. During the succeeding evenings, when the larvacide was applied, discomfort from mosquitoes was insignificant, and the audience was well pleased. Subsequent observations have disclosed practically no injury to the shrubs and trees, and only slight burning to the grass blades.

Thus far the larvacide was found effective against the following species of mosquitoes: *Culex pipiens*, *Aedes vexans*, *Aedes sollicitans* and *Mansonia perturbans*. Tests will be conducted against other species whenever available.

The formula of the present New Jersey mosquito larvacide, which has recently been improved to be compatible with hard and salt water, is as follows:

Formula for Tank Preparation.—100 gallons kerosene containing pyrethrum extract equivalent to 1 pound of flowers (analysing 0.9 per cent pyrethrins) per gallon; 50 gallons water; 6 pounds sodium laurel sulphate (emulsifier).

The emulsifier is first mixed with the water and transferred to the tank. The oil is then run in gradually into the tank, with agitators and pump working at full speed. After all the oil has been aded, the pumping is continued until the entire mixture has passed through the hose and back into the tank two or three times or until the mixture is thick and homogeneous, showing no free oil on the surface. The finished product is then pumped into drums for storing. This constitutes the stock emulsion. Excessive foaming may be eliminated by dissolving about two or three pounds of wool grease (Degras) in the kerosene before emulsifying. Any other suitable apparatus for emulsification can be used.

The cost of preparing the concentrated emulsion is about 23 cents per gallon, based on the present price of pyrethrum, which makes out slightly over 2 cents per spray gallon. When purchased, the stock emulsion costs from 30 to 50 cents per gallon, depending on the quantity ordered.

While this larvacide, when prepared and applied as directed, is apparently safe on vegetation, as brought out by the results thus far reported, further experiments are at present being conducted in order to verify the above findings under all kinds of conditions and on many varieties of plants.

Reviews

THE USE AND MISUSE OF LAND, R. M. Gorrie, Oxford Forestry Memoirs, No. 19, 80 pp.: Oxford, Clarendon Press, 1935.

FORESTS IN RELATION TO CLIMATE, WATER-CONSERVATION AND EROSION: Union of South Africa, Dept. of Agriculture and Forestry, Bull. No. 159, 1935; 6d.

Neither of these two publications draws upon East African material for its argument, but they contain much that will evoke interest here. Both deal with the almost universal problem of the deterioration of land (more especially forest land) through man's clumsiness in putting it to his uses. Both maintain, with abundance of examples ancient and modern, the thesis that natural forest, even if it is only a xerophytic scrub, is to the country that possesses it an asset not to be dissipated except on pain of misfortunes wholly disproportionate to the immediate gain on realization. There is, however, no pedantic insistence on leaving forest entirely unexploited. The emphasis is on the *use* of land, but with the proviso, so often disastrously neglected, that intelligence and foresight shall be applied so as to avoid too great a disturbance of natural balances.

While thus they preach a common cause, the two publications differ to extremes in method and appeal. *The Use and Misuse of Land* is sponsored by a learned University, as notable nowadays in leading the van of thought as once it was as the home of lost causes. It is the report of a Leverhulme Research Fellow, who already had long experience as a forest officer in India, on a study of present-day American work in the control of forest land utilization. He presents, with an analysis of the circumstances of each, examples of land classification and regional planning, of survey for the assessment of grazing potentialities in forest, scrub and open range, of over-grazing and its effects, of the value of vegetational cover in stream-flow control, of forestry as a factor in farm and village economy, and of ameliorative works on land that has suffered soil loss or gullying through accelerated erosion. In each case there is sufficient detail, and, for many, diagrams or photographs. Yet it is by no means a mere case-book, for there is much constructive and critical discussion, and a statement of ideals in land-use organization—some of which he finds here and there already embodied in practice. "Under most so-called 'popular government' systems," he says, "the long view necessary for sound forestry and land-use planning is apt to be sacrified to temporary gains, or to the force of political pressure. . . . It is worthy of note that the countries which are at the moment making greatest strides in organized land development—namely, the United States, Italy and Russia—are those in which 'popular government' has surrendered to, or been replaced by, autocratic control by a few men selected for their technical ability." Apart from such high constitutional matters, however, this paper should command wide attention, in quarters both administrative and technical, for the principles it advocates. In any event, there is stimulation in the examples of practice—not only, be it said, from the United States, but also from Canada, India, continental Europe, and New Zealand.

The South African bulletin is issued by a Government department evidently somewhat concerned to defend its activ-

ities against critics. It consists mainly of a number of speeches of interesting and varied content delivered to the Fourth British Empire Forestry Conference at Durban in September, 1935, and is prefaced by a formal report of the findings of a committee of that Conference on the subject that forms the title of the paper. Speeches and report are alike polemical rather than scientific in style, and there is betrayal of a tendency to reject unwelcome evidence if it is "at variance with the generally accepted conclusions." The publication as a whole has somewhat the manner and phraseology of a congress of Anglican bishops pronouncing upon questions of the day, and rebuking the advanced views of a fellow-member of the bench. One suspects also that in some of its technicalities the subject set to the committee lay outside the main field of their professional competence. For these reasons, their report does not entirely carry conviction. It does, however, draw attention, by its very attempts to deprecate its importance, to a controversial point of great interest, raised by Professor J. F. V. Phillips, of Johannesburg, formerly of the Tsetse Research Department in Tanganyika.

This concerns the consumption of water by growing trees, and the resultant effects on the flow of streams from forested watersheds. Phillips maintains that certain commonly planted exotics, notably wattles, gums, and, to a less extent, conifers, have a greater requirement for transpiration than the native species they replace; so much so, that they may actually defeat one of the proclaimed objects of afforestation, and reduce rather than augment the local supplies of permanent water. To this it is objected (and, to a degree, soundly) that even if it be so, it is better to use water profitably in the production of timber than to let it run idly to waste, carrying with it the unprotected soil over which it flows. The point is, however, that you cannot both eat your cake and have it; if in any locality water conservation is your principal purpose, along with soil protection, then in that district you must be content to let timber profits take second place, and rely on the slower growing and less demanding natural forest types for your vegetative cover. The matter is complicated also by the possible, in some cases well known, effects of pure stands of introduced trees, and of the leaf litter beneath them, on tendencies in soil deterioration.

The position of this controversy in South Africa does not concern us, except as onlookers. We shall do well, however, to adopt the scientific rather than the authoritarian attitude towards the same problem as it arises in East Africa, where in many parts the security of water supply is undoubtedly of more fundamental concern to the population than is the provision of exportable forest produce. The two attitudes are well contrasted in the following quotations on this very subject:

Dr. Gorrie, in the Oxford memoir under review (p. 53): " The whole question of transpiration and evaporation from plant cover under arid climates is a very open one, and points to the need of much further research in each district where the issue is of importance, for generalizations in a matter of this sort are exceedingly dangerous."

Mr. J. D. M. Keet (one of the signatories to the report referred to above) in "A Plea on Behalf of Forestry," *Farming in South Africa*, Feb., 1936, p. 52: "The parentage of the spring in the tree that shades it cannot be denied."

G.M.

A PROVISIONAL SOIL MAP OF EAST AFRICA (*Amani Memoir* No. 31), by G. Milne, East African Agricultural Research Station, Amani, in collaboration with V. A. Beckley and G. H. Gethin Jones, Department of Agriculture, Nairobi; W. S. Martin and G. Griffith, Department of Agriculture, Kampala; and L. W. Raymond, Department of Agriculture, Zanzibar.—To be obtained from the East African Agricultural Research Station, Amani, Tanganyika Territory, or from the Crown Agents for the Colonies, Millbank, London, S.W.1; price, 5/- post free.

This keenly awaited map, accompanied by a concise descriptive and explanatory text, is a most valuable contribution to our fundamental knowledge of East Africa. Its compiler and his collaborators fully deserve both sincere congratulations and the highest praise from all interested in the soils of the four dependencies; and none will be more grateful than the geographer, not only for the material provided but more particularly for the synthetical spirit in which it has been treated.

The printing of the map—on light but stout paper—is clear and pleasing to the eye, although in artificial light the greens and blues and the reds and oranges are not as easily distinguishable as in daylight. The reading of the pattern becomes simple once one has grasped the logical methods used for the representation of the adopted soil classes.

Classification, in soil as in any other science, is of course unavoidable, and remains useful as long as one remembers that the phenomena of nature always merge into one another and that therefore, at the best, we obtain only a generalized picture of a highly complicated reality. The authors have accordingly been wise in refraining from too much subdivision and in restricting themselves to a relatively small number of major soil groups. Theoretical and practical wisdom is also shown in the attempt to base the classification on soil morphology, especially in a region so intricate as East Africa in its geological and climatic pattern, and one that has been subject to great tectonic and climatic changes in the recent past. That this attempt is a first approximation only is admitted throughout, as is also the fact that at the present, as yet very limited, stage of our knowledge it is the geographically minded "land-planner" rather than the practical tiller of the soil who will benefit most from the study of map and text.

The short chapter containing "General Conclusions" deals lucidly and inspiringly with the factors determining soil types, with the all-important persistence of effects from past time, and with soil in relation to land classification. One misses, however, reference to fire and the activities of man among the factors influencing and modifying the natural genetic history of many African soils.

Among a great number of features that appeal to the present reviewer, the most outstanding is Milne's concept of the "catena", by which "the schematic representation of an association or physiographic complex of soils, defined in general terms in relation to a set of conditions," becomes easy and clear. This "catena" as well as the adopted diagrammatic mapping of other non-catenary complexes are indeed the only possible way of doing justice to the facts of nature on a small-scale map and with the limited knowledge at the compiler's disposal.

C.G.